Air & Space

National Air & Space Museum
Smithsonian Institution

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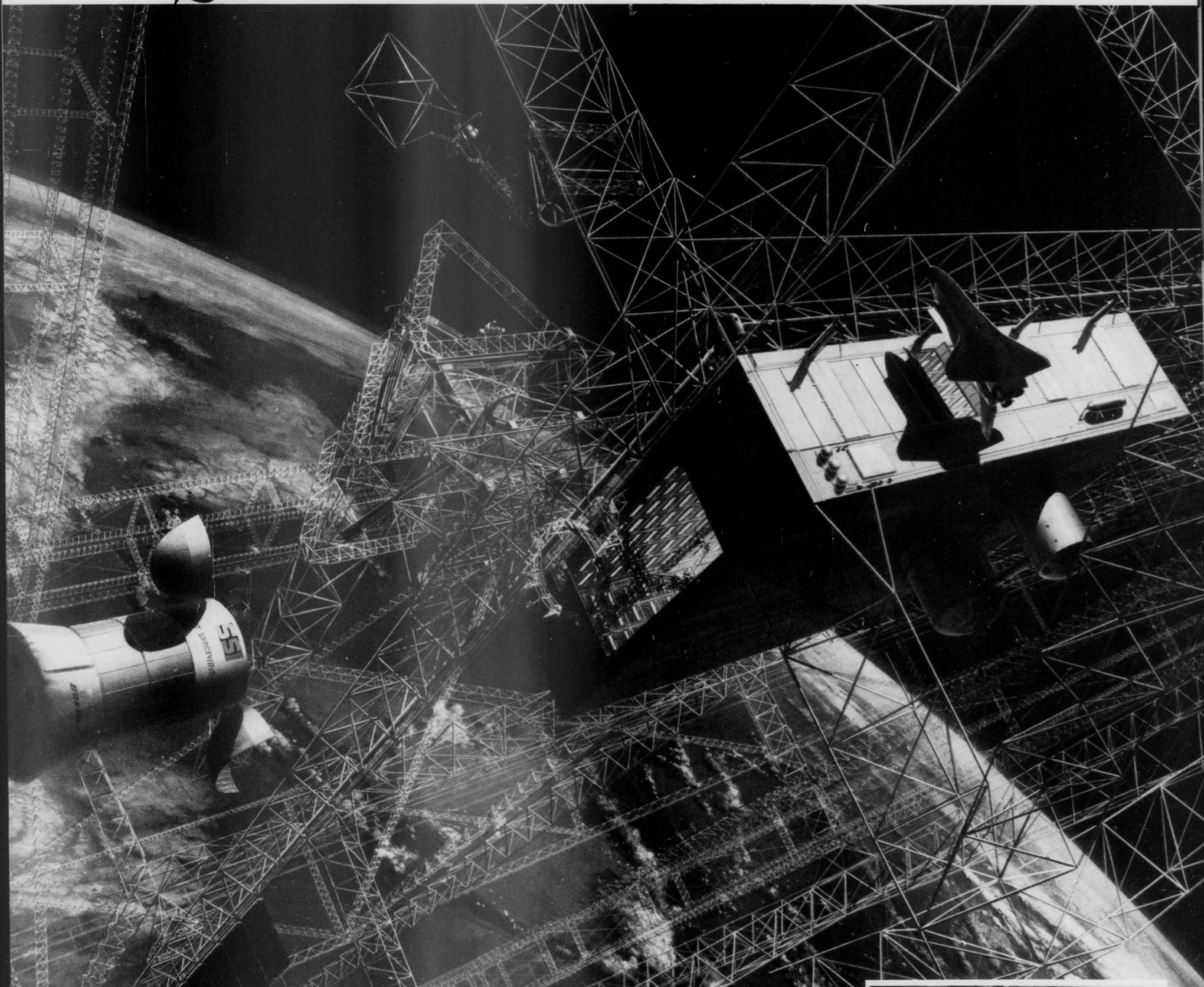

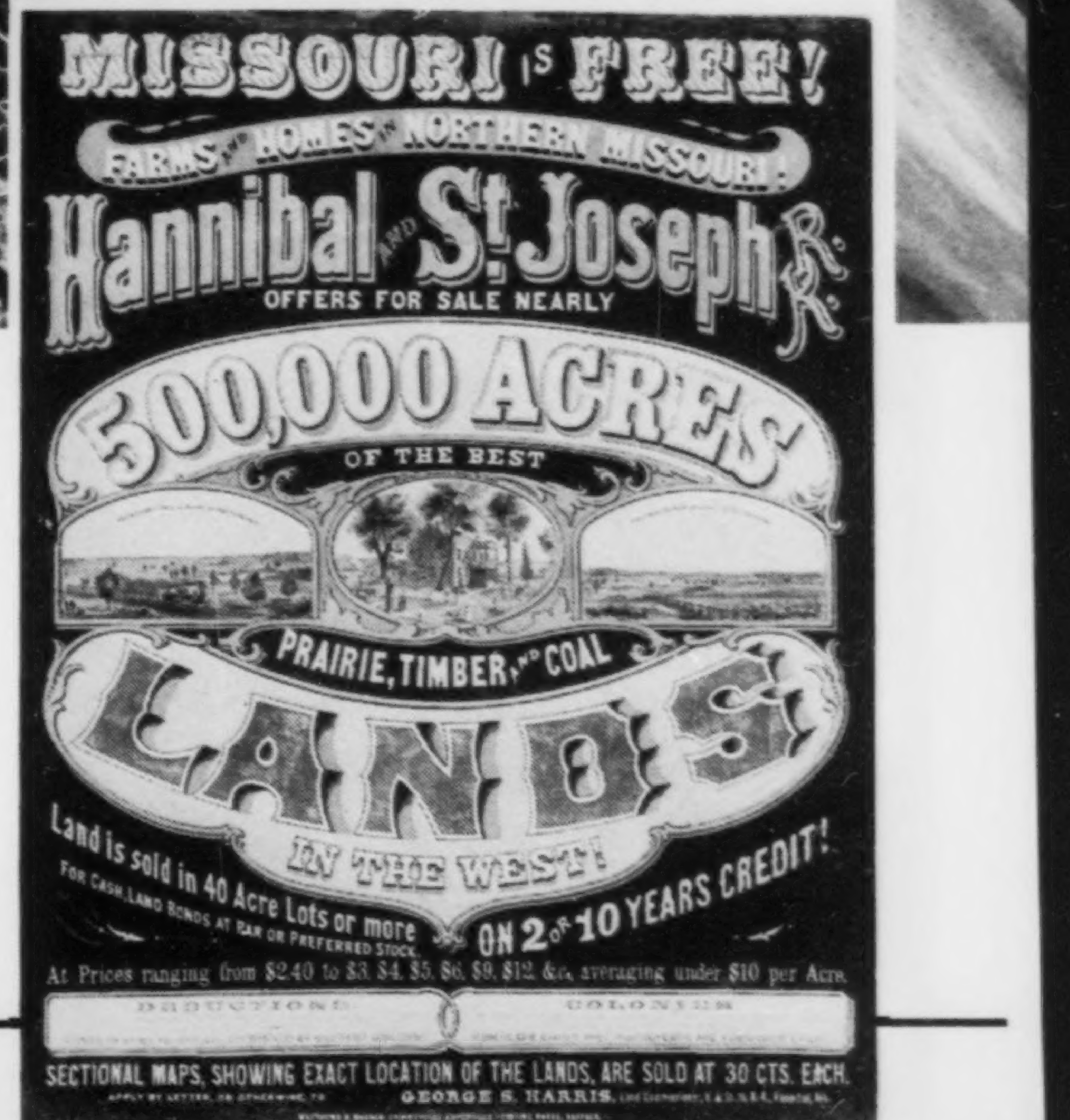

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GEORGE S. HARRIS.

Transportation to new areas opens frontiers. In the past century, railroads lured pioneers West with posters like the one to the right which pictures a fine homestead on rich lands. Now, NASA will start routine cargo service to space in the early 1980s with reuseable Shuttle orbiters. Again, artists depict an exciting future on the new frontier. Above, an orbiter is seen toward top right, unloading cargo while "upside down" over a port in the core structure of a satellite solar power system. More on Shuttle, Pages 3-6.

SCAN

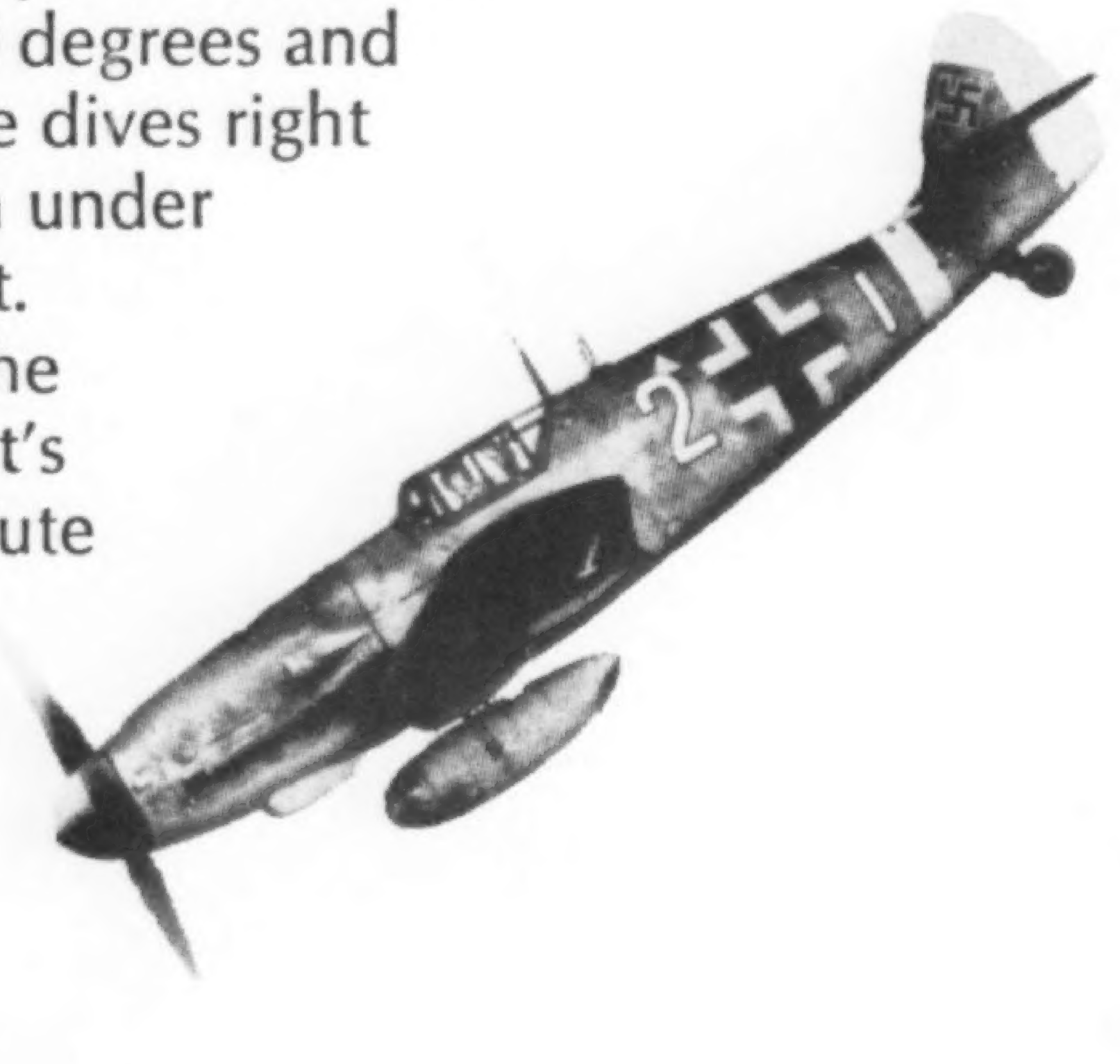
For brevity, the National Air and Space Museum is often referred to in these pages as NASM.

On Pages 7, 8 and 9 are drawings and a story that enable dexterous readers to build a personal Bf 109 Messerschmitt—at a scale of ¼″ = 1′0″.

"The nimble Messerschmitt is still remembered . . . for its exploits during the epic battle of Britain," writes Robert C. Mikesh, Page 7. But Messerschmitts did not end their days with the Hitler defeat. The Israelis, who bought Messerschmitts from Czechslovakia, fought Egypt's Spitfires with them until 1948. Switzerland flew versions until 1949, the Finns and the Czechs until the 1950s. Spain was the last to give theirs up, selling 27 single-seaters and one two-seater to J. Arthur Rank Productions for use in the 1968 film, "The Battle of Britain." Then the craft were dispersed, to museums mostly, but four of them went to the Confederate Air Force (CAF), which incidentally is now a corps of 4,000 Colonels throughout the world.

Air & Space talked to the CAF's Director of Operations, Bob Griffin, at Rebel Field, Harlingen, Texas.

"The Messerschmitt handles well in the air," he said. "In fact, you point the nose down 10 degrees and the plane dives right out from under your seat. But on the ground it's an absolute terror."



When the wheels hit expansion joints in a concrete runway, the plane darts right or left. Its awkward stance (see drawing, Page 8) comes from engineering problems in retracting its gear into such a thin wing. Landing was better on the grass pasture fields of the 1930s. "Nevertheless," said Mr. Griffin, "of 33,000 Messerschmitt 109s built, 10 percent were lost in accidents during landings or takeoffs."

After World War II, most Messerschmitts were fitted with Rolls Royce Merlin engines, the kind that had powered their foes in the British Royal Air Force. The Bf 109 on exhibit at NASM, however, is vintage German with the original Daimler-Benz engine.

Briefing

Melvin B. Zisfein
Acting Director, NASM

This issue of *Air & Space* features the Messerschmitt Bf 109, one of the all-time best fighter aircraft and the principal foe of British fighters during the early portions of World War II—such as during the Battle of Britain.

This column, which you are reading during or after January 1979, was actually written in early October 1978. In between these two dates a fascinating evening event took place in the National Air and Space Museum Theater—a round table discussion of the Battle of Britain, with two of the best pilots who fought in the Battle. They were Lieutenant General Adolf Galland, General of the Fighter Arm of the Luftwaffe, and Wing Commander Robert Stanford-Tuck, a famous Battle of Britain pilot.

The Battle of Britain was, of all of the conflicts that I have ever studied, one of the closest and one which practically invites us to speculate in a game of "whatif."

For instance, what if Neville Chamberlain, who became infamous as the appeaser of Hitler at Munich, had not appeased? The extra year given to Britain between Munich and the start of World War II enabled England to increase its strength by more than 400 fighters (mostly Hawker Hurricanes), raising British squadron status from a mere four equipped with modern fighters to 27. It could be argued that the extra year spelled the difference between victory and defeat for Great Britain in the battle when it finally came.

And what if Winston Churchill had come to power earlier? Well, there's no doubt that Churchill was one of the great leaders of all time and that to many of us he symbolizes the matchless British determination shown so splendidly in the Battle of Britain. On the other hand, Churchill's science advisor was Dr. F. A. Lindeman (later Lord Cherwell) who doggedly opposed the development of radar in the mid-1930s as likely to be unproductive. If Great Britain had not developed its "chain home" and "chain home low" radar networks, and the systems tying these to fighter control, I'm certain that they would have lost the battle. Could Lindeman have stopped the development of radar in, say, 1936, if Churchill had been in power then? There's no way to know, but it makes for interesting speculation.

And what about Hermann Goering, Hitler's air chief? When provoked by a raid on Berlin, he stopped attacking British radar stations and fighter airfields and started dropping bombs on London and other cities. This switch occurred about a month or two before the point where some scholars say the Luftwaffe would have beaten the RAF, had it continued its anti-radar and airfield attacks. Indeed, it is possible that the time Goering switched from attacking the British fighter and radar stations to the brutal killing of civilians in London was the time when he began to lose the Battle of Britain.

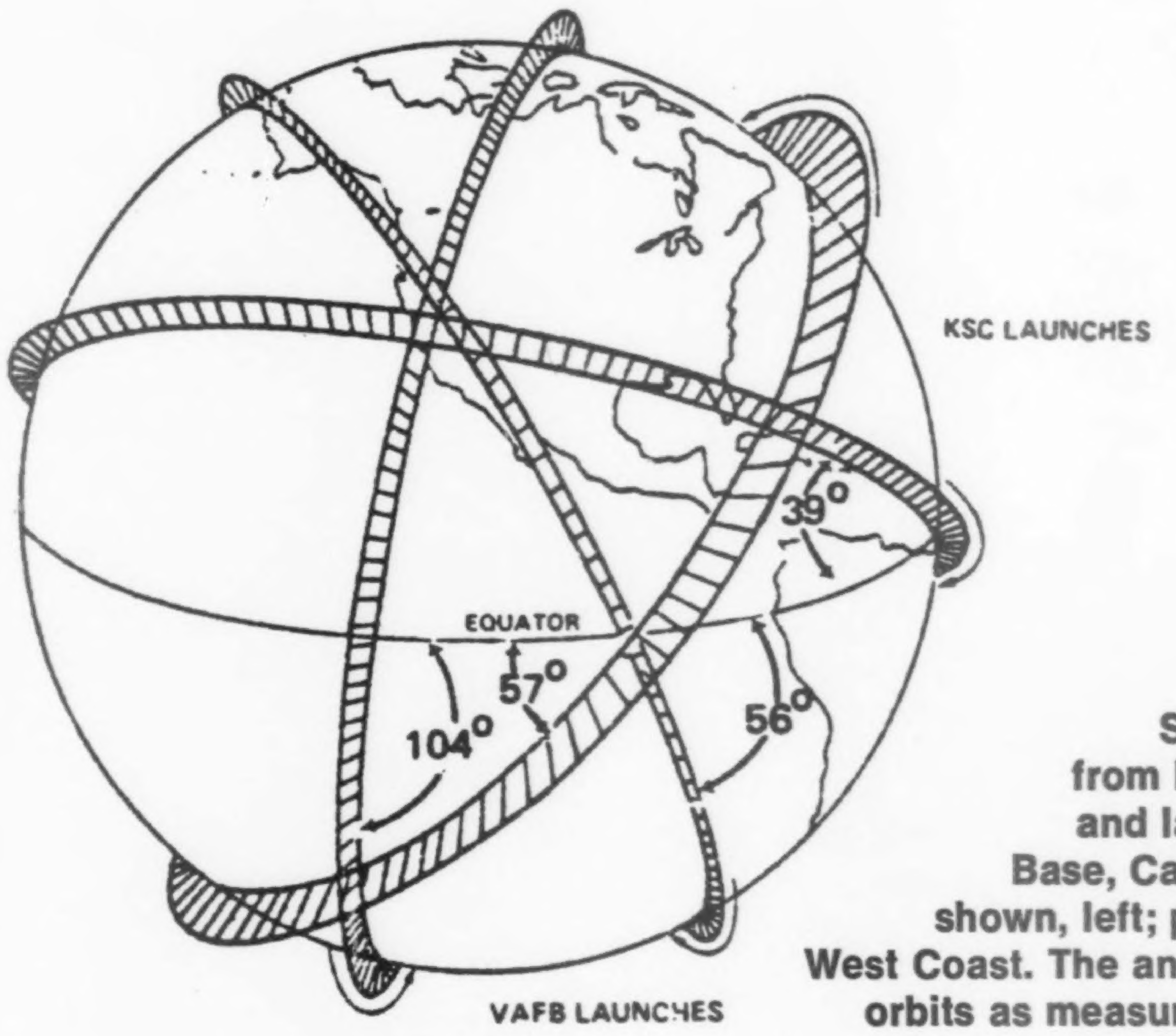
As I said when I started this column, the Battle of Britain, one of the closest of all battles, makes for fascinating speculation. To the teachers reading this column, perhaps you could duplicate our debate, by appropriate assignments and debate in your classes.

TO FIRST-TIME READERS: Please see notes on Page 15.

SEPTEMBER 1979: FIRST SHUTTLE FLIGHT, A MILESTONE IN

The Expanding Domain of Human Occupation

Until the Wright brothers showed how to sustain controlled flight, in 1903, people's work had always been limited to Earth's surface. Now, aircraft swarm through the atmosphere above that surface, adding a useful shell 10 to 15 kilometers wide all around this world. Next, as Edwards Park of the *Smithsonian* magazine noted, the Space Transportation System (STS) will suddenly enlarge the shell to a width of 260 km. In the STS operation, Shuttle orbiters will be launched on regular schedule into space. Sometimes, orbiters may circle Earth just outside the atmosphere (which begins to offer serious drag at about 122 km) or swing far out on elliptical paths, according to the work to be done. But typically, orbiters will carry astronauts and experimenters around in a circle at about 260 km altitude. Among the jobs will be unloading permanent satellites, usually with their own rocket motors to push them to higher altitudes. Already, space between Earth and geosynchronous altitude (35,700 km) is populated with dozens of working satellites from many nations, actually extending Earth's presently unmanned but constantly used shell to a width of 35,700 km.

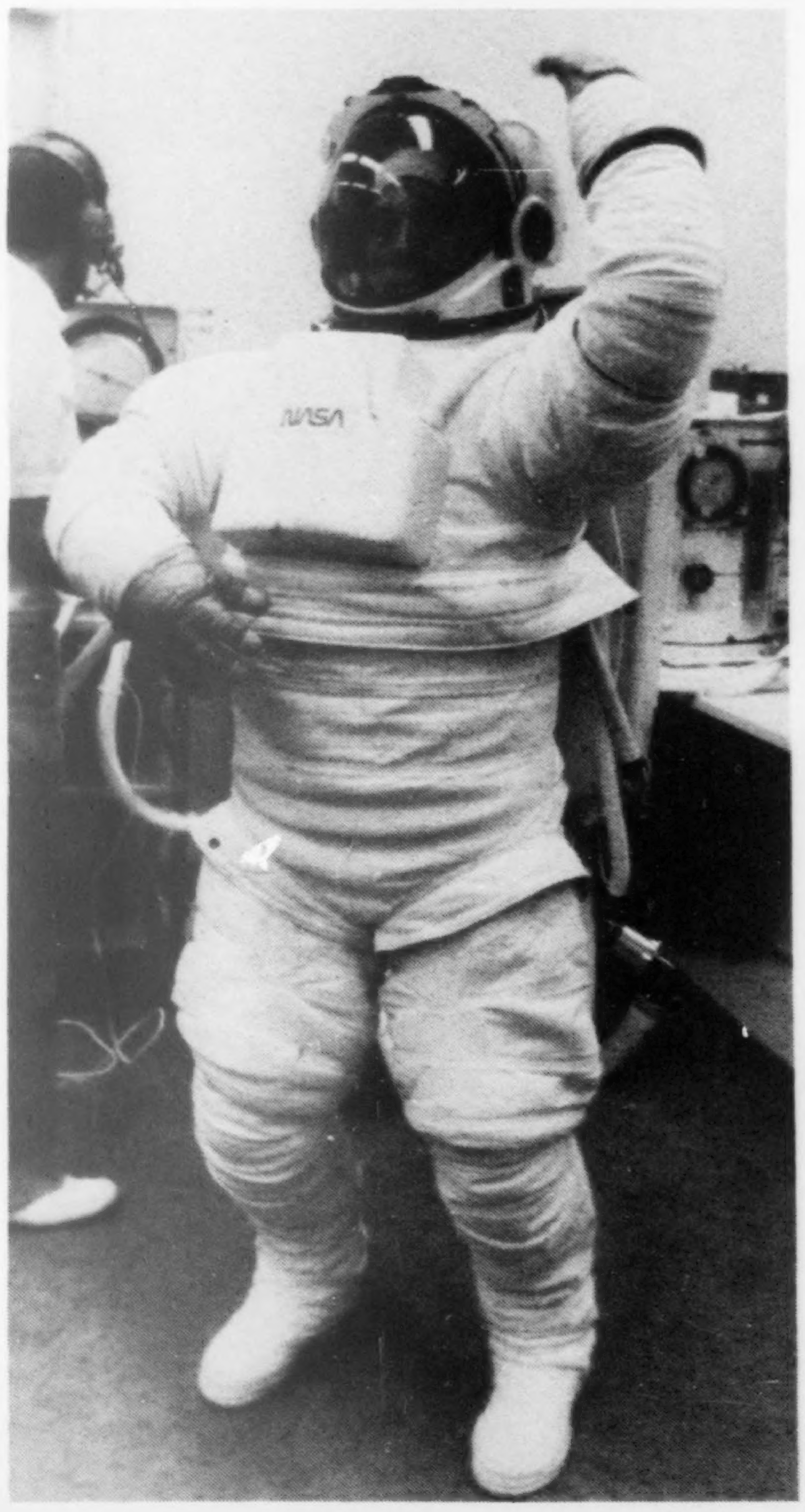


Shuttle orbiters will be launched from Kennedy Space Center, Florida, and later from Vandenberg Air Force Base, California. The resulting paths are shown, left; polar orbits will originate on the West Coast. The angle-degrees show inclination of orbits as measured clockwise from the equator.

Will life adapt

to the high frontier? The orbiters' living quarters will have a breathable atmosphere, familiar pressure and temperatures. When astronauts work outside on Extravehicular Activity (EVA), they go encased in life-supporting suits (photo at right). But weightlessness always prevails. "Is it a nice, dreamy feeling?" a student asked this publication.

Maybe dreamy with disorientation, but not always nice. So far, astronauts have been intensively trained men of strong discipline and pride, not readily admitting that any of them may have been sick and nauseated. (Soviet literature about cosmonauts is much more vivid.) With ingenious instruments, physicians carefully monitored astronauts in space and learned a great deal about calcium drain, redistribution of blood, deterioration of muscle, and such. After all, through the eons, Earth life has never experienced anything but the downward pull of gravity which for Earth is termed "1 g." In space, suddenly all systems are adrift. Astronauts have shown some signs of beginning to adapt to weightlessness; the longer they stay in space, the longer it takes to readapt to Earth's 1-g.



Below, astronaut John W. Young, commander of the first Space Shuttle flight, tries a new type pressure garment designed for both men and women of future Shuttle crews.

What will change

when the Shuttle system begins providing regular service to space?

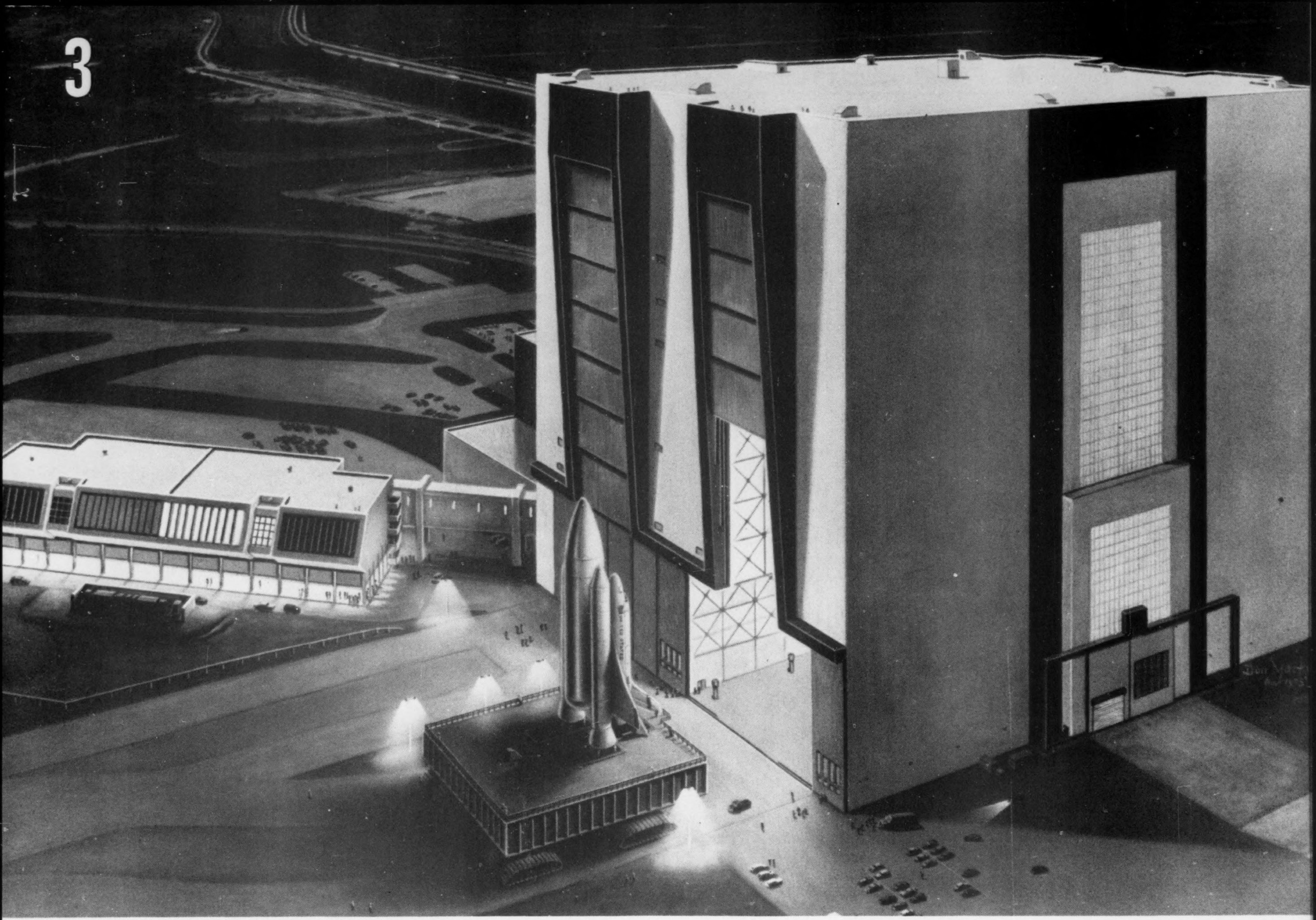
The costs of getting there will drop. The costs of building a satellite will drop. Now, satellites are often multimillion-dollar investments, with redundant systems and extraordinary technology because a failure in space is an irrevocable loss. Of the few lost so far, most could be termed cases of "infant mortality"—failures during launch or soon after reaching orbit. When put up in the cargo bay of a Shuttle orbiter, however, the unit can be checked by astronauts before it is unloaded into space. If some element should fail later, another orbiter can rendezvous; astronauts can make repairs or stow the thing in the cargo bay for return to Earth.

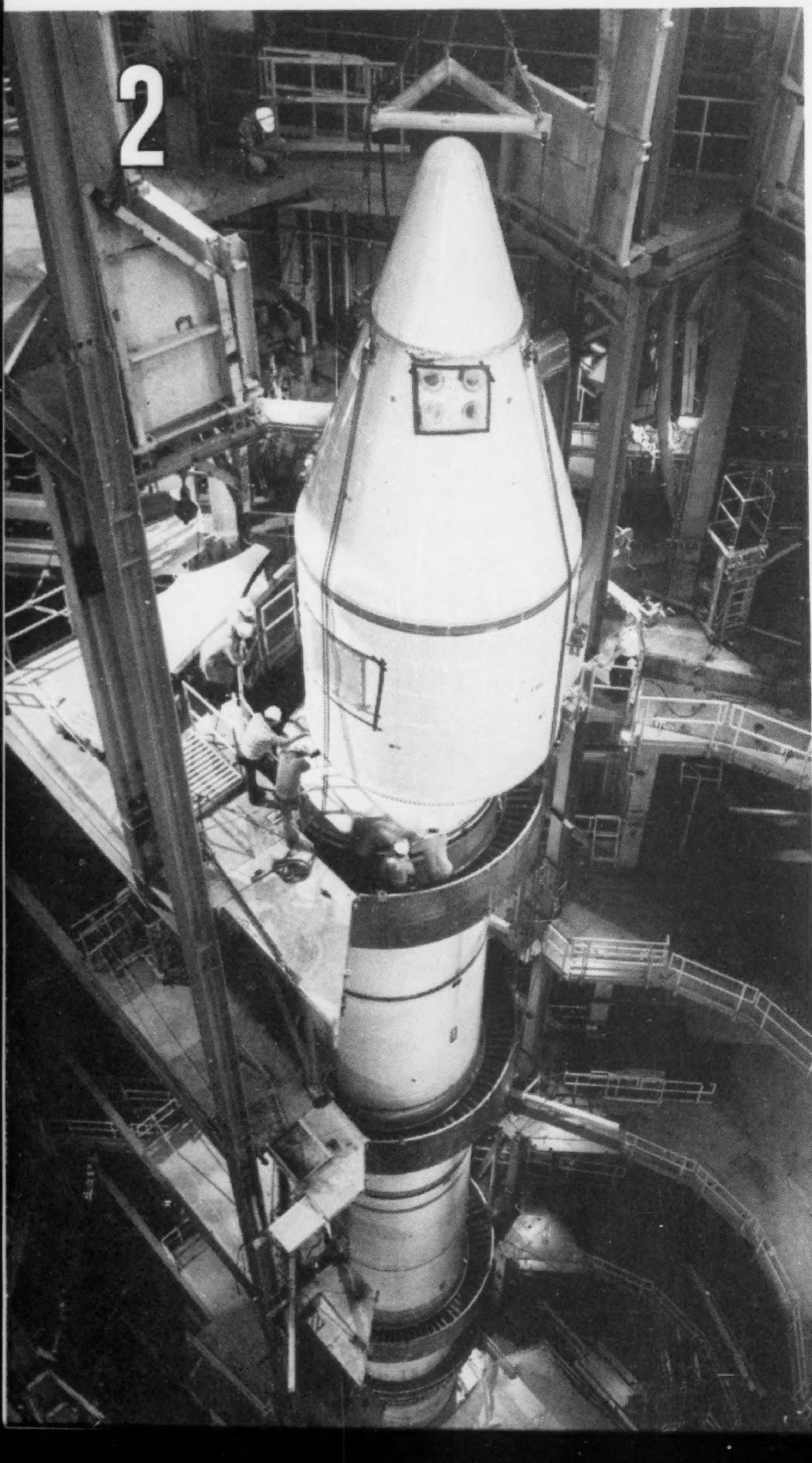
At last, scientists will be able simply to pick up their regular laboratory equipment and carry it along to space. No longer will instruments need to be redesigned in miniature, provided with recorders or transmitters, and cushioned against the drastic vibrations typical of launches so far. (Shuttle launch is gentle.)

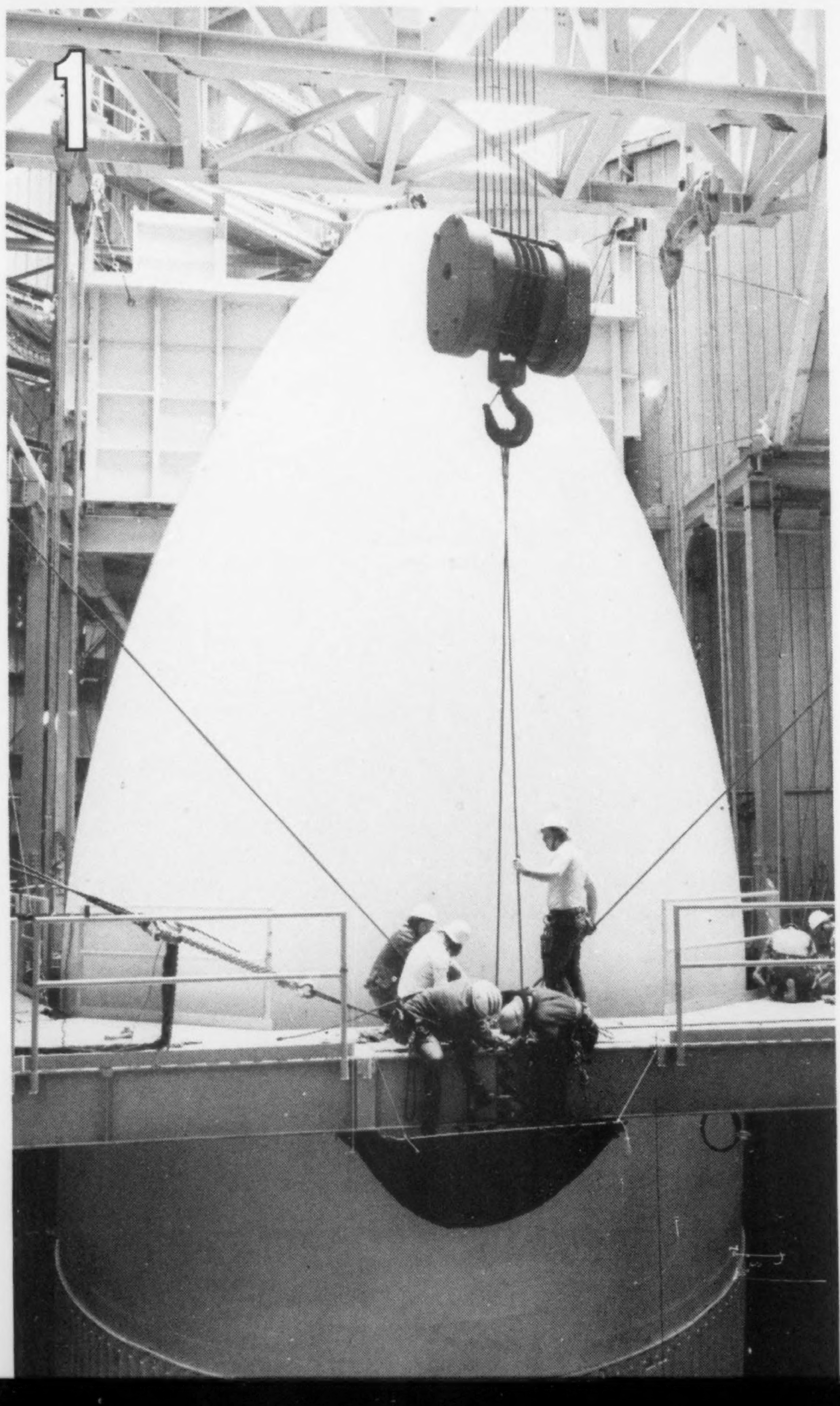
Advantages of Space

In space, scientists have access to a good vacuum. A better vacuum can be created on Earth but the process becomes expensive if containers are large. The temperatures and some radiations of space can be duplicated on Earth. Weightlessness, however, can be simulated for only a few seconds at a time

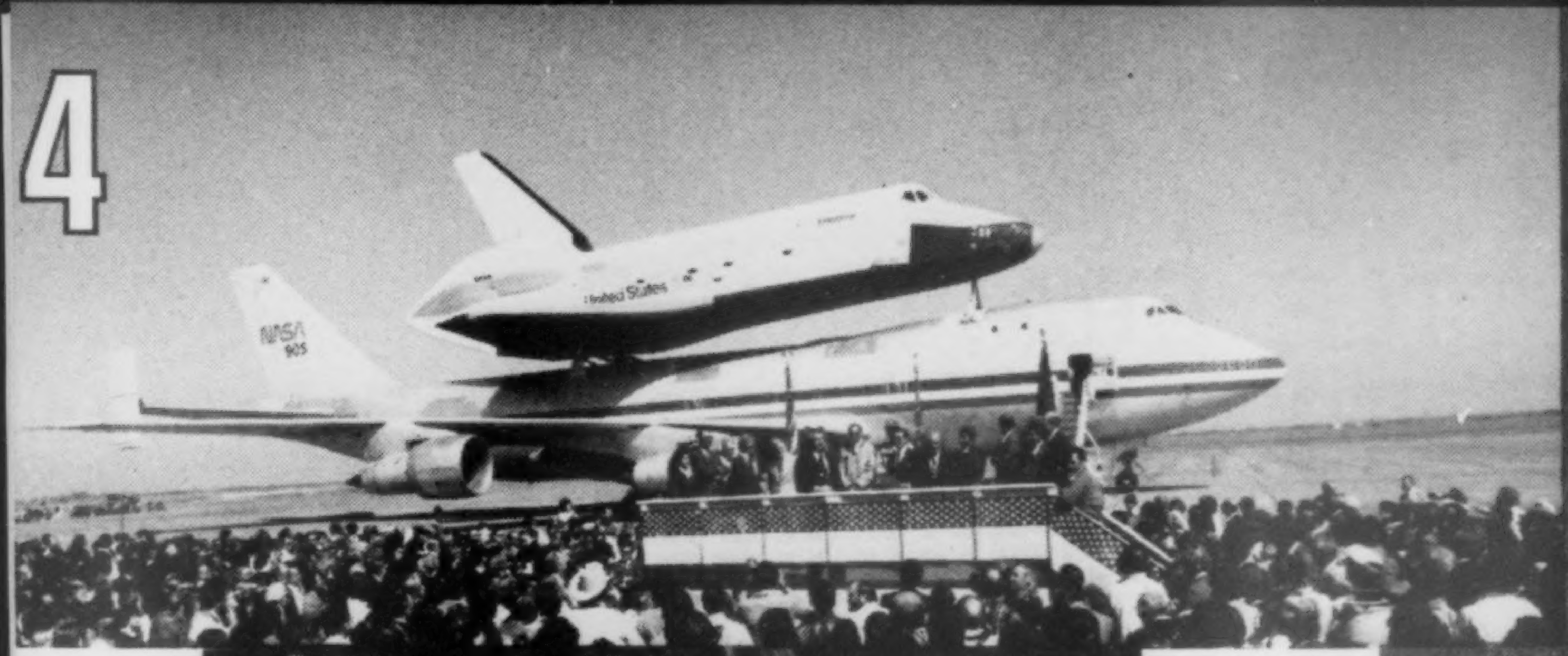
Continued on Page 15







1. **First left: The external tank for liquid propellants (fed to the orbiter's main engines during launch) is seen in the test stand at Marshall Space Flight Center.**
2. **One of two solid fuel boosters is being assembled for tests simulating launch.**
3. **Artist's concept: a flight-ready system (external tank, boosters and orbiter on the launch base) is being rolled out of Kennedy Space Center's Vehicle Assembly Building on top of huge crawler.**
4. **Orbiters ride piggy-back on a 747 for transport from place to place on Earth. This is not how they are launched.**
5. **The crawler has deposited the launch base with Shuttle assembly over flame pits at the launch pad.**
6. **At launch, solid fuel burns quickly; booster casings separate, deploy parachutes, drop into the sea for recovery and reuse. The external tank is jettisoned later.**
7. **In space, mission specialists overlook the cargo bay and can move payloads by use of a remote manipulator arm.**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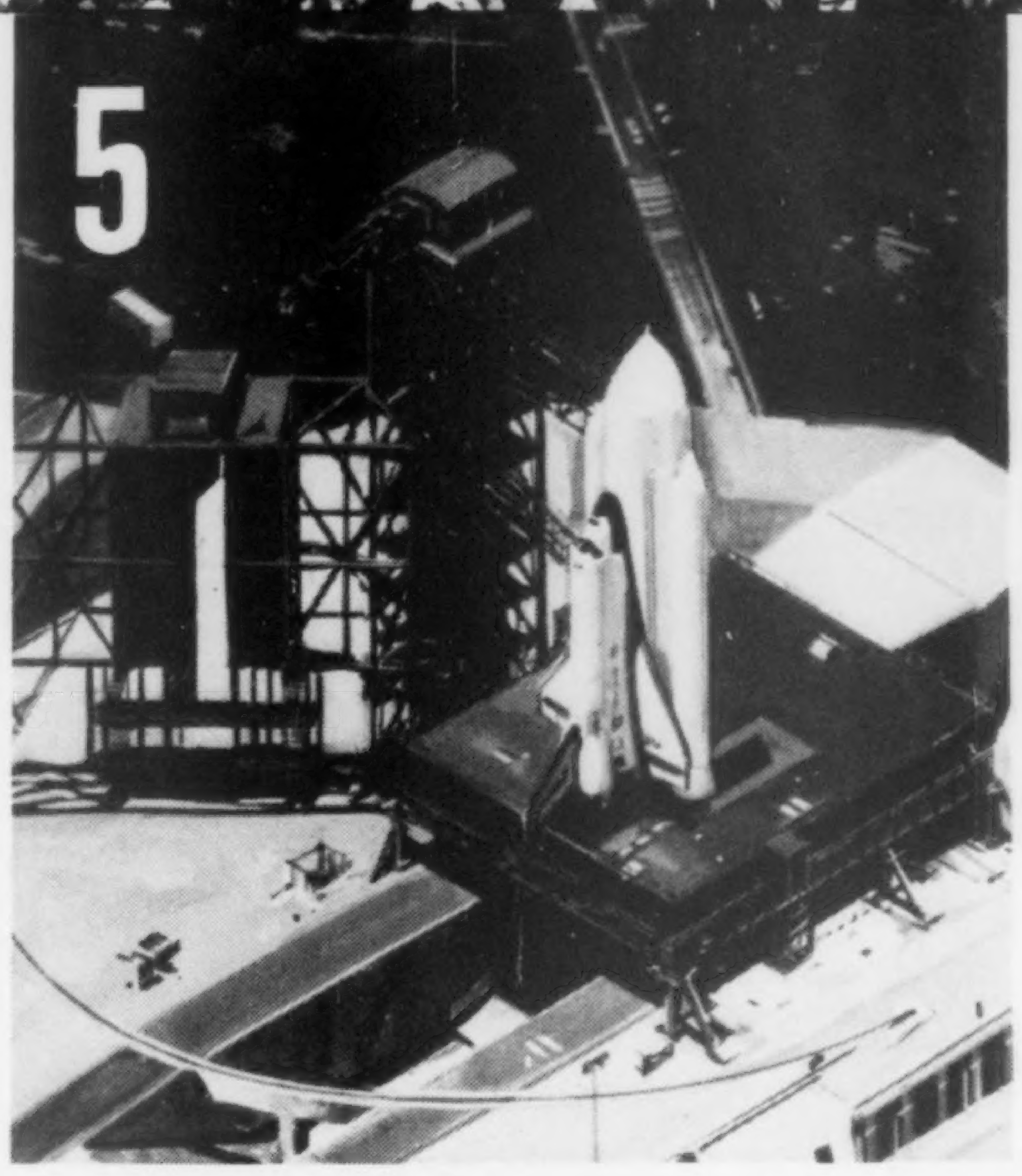
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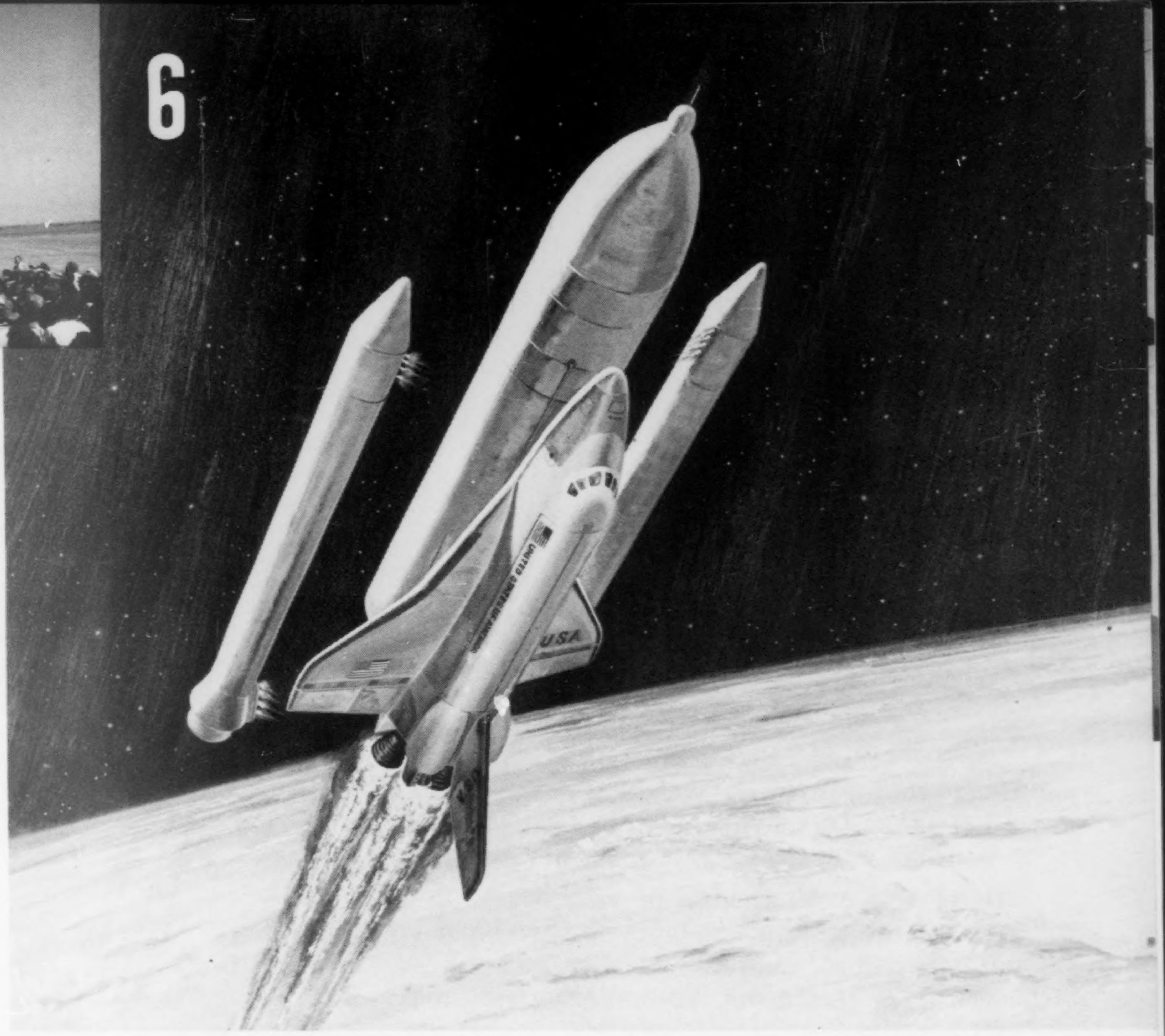
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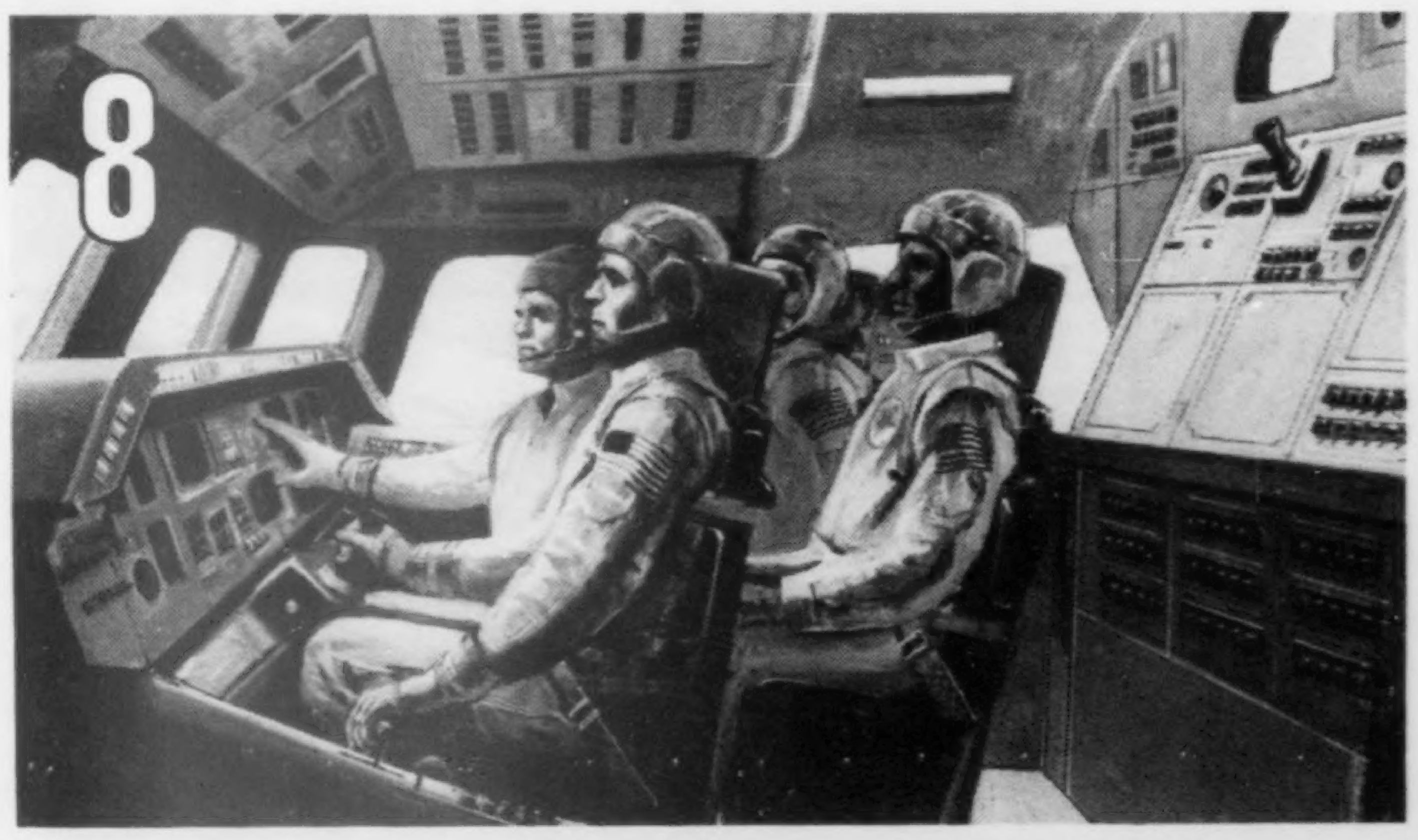
The Shuttle Cycle

Start with Picture No. 1, lower left.

Other picture-stories coming in *Air & Space*, March and May, for class use next fall when Shuttle is scheduled for its initial flights.

8. Commander and pilot (in front), mission specialist and a payload specialist return to Earth.
9. Without power, orbiters return as gliders. A covering of two kinds of special tiles dissipates heat as high as 1925 K (3000° F.) from friction of atmospheric entry at 14,450 kilometers per hour.
10. Orbiters are designed to be refurbished and reloaded for successive trips to space.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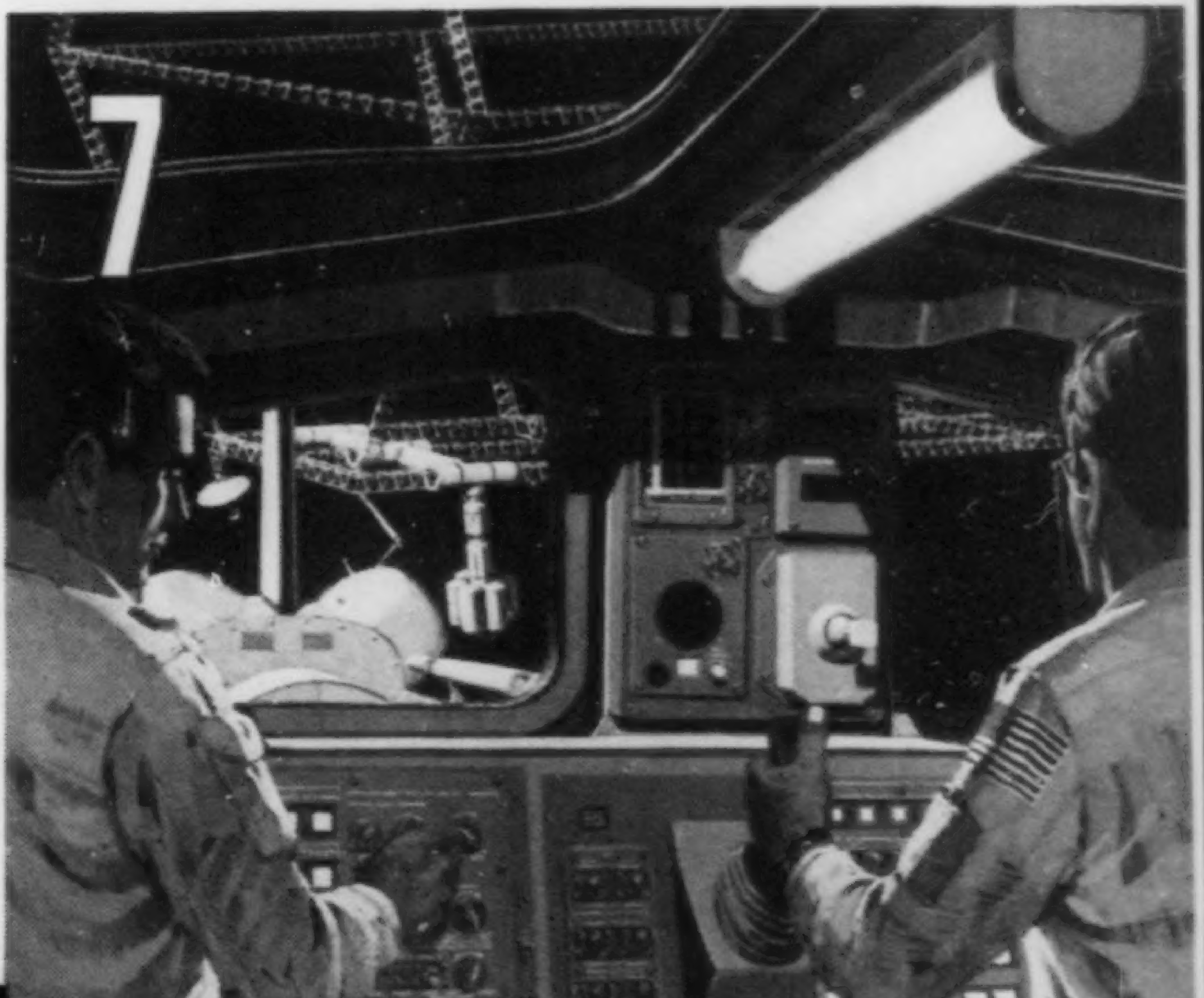
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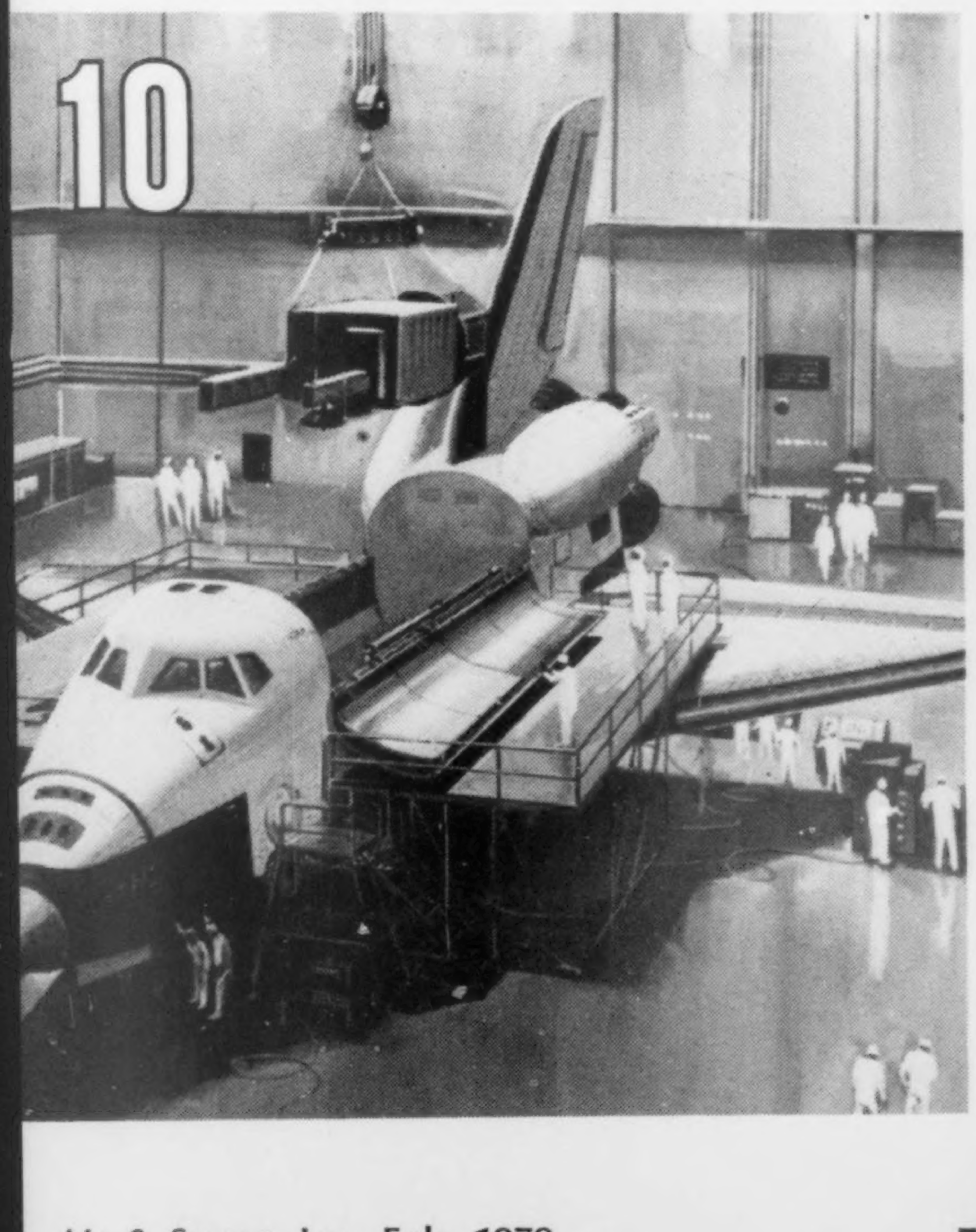
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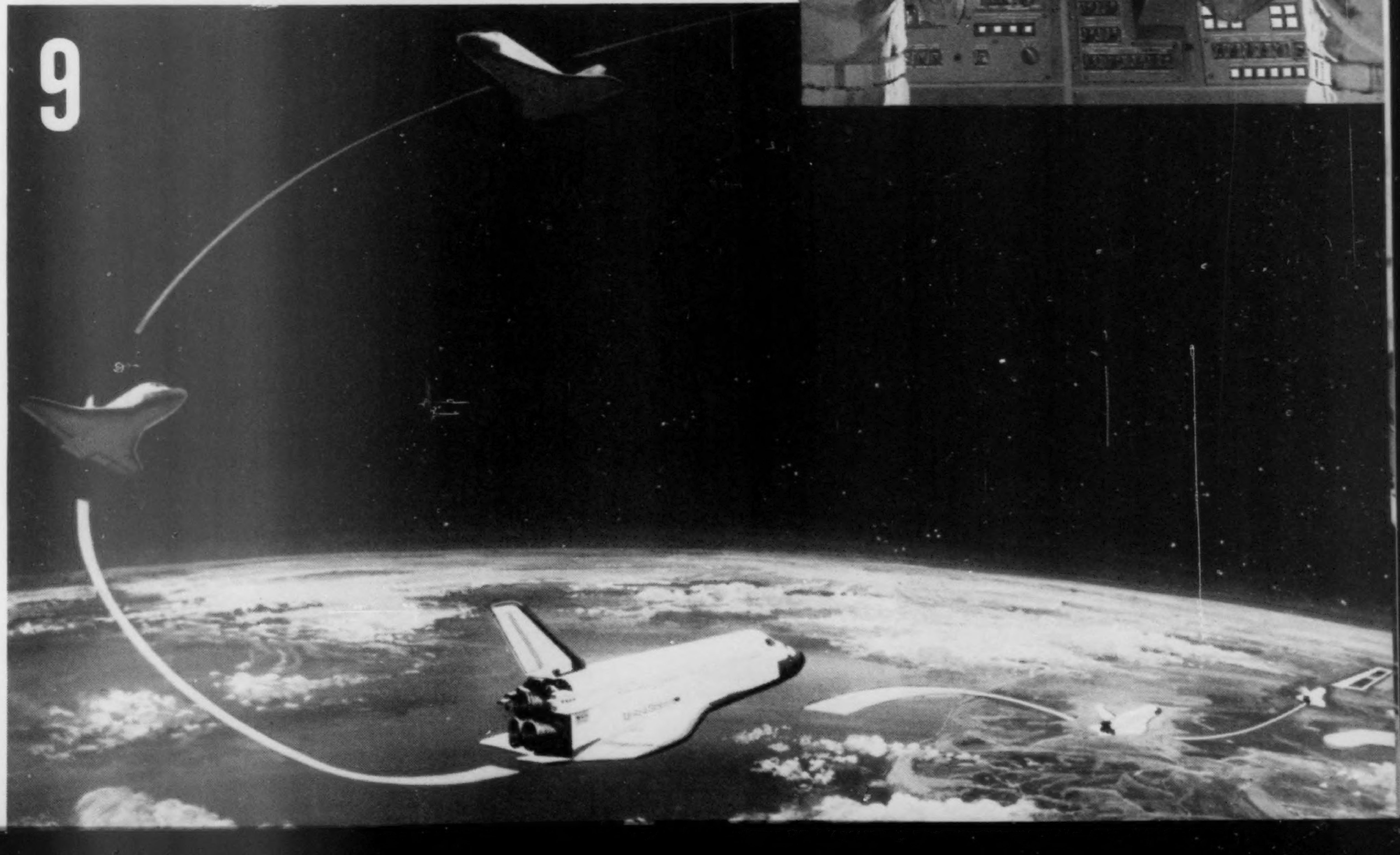
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GLOSSARY

SHUTTLE ERA TERMS

Airlock—Area that can be depressurized without affecting pressure in the crew compartment; used for transferring crew/equipment from cabin to cargo bay or space.

Atlas-Centaur class—Payloads weighing 1,800-2,000 kilograms, launched now on Atlas-Centaur boosters.

Azimuth—True launch heading measured clockwise from 0° N.

Barbecue mode—Orbiter in a slow roll for thermal conditioning (temperature control).

Dedicated flight—All orbiter facilities reserved for one purpose.

Delta class—Payloads weighing 900-1,100 kg, launched now on Delta boosters.

"Delta V"—Δ V, change of velocity: "The orbital maneuvering system (OMS) delta-V reserves are 6.7 m/sec and 12.8 m/sec for no-rendezvous and rendezvous, respectively."

External tank (ET)—Large tank for liquid propellants fed to an orbiter's three main engines during launch; it is to separate near orbital entry, fall, and disintegrate over a remote area of the Indian or South Pacific Ocean. There are proposals to load extra propellant necessary to carry it on up to orbit as a unit for a space station.

Extravehicular activity (EVA)—Work by space-suited crew members in the open cargo bay or in space.

Free-drift—Orbiting without powered control. Sketches at right show three attitudes relative to Earth.

Free-flying system—Any unit detached from the orbiter for independent operation in space. Examples: the Large Space Telescope, and the Long Duration Exposure Facility (LDEF); more on these in *Air & Space* later.

Gravity—The attraction exerted by masses on each other. An orbiter is not beyond the Earth's gravitational field, and so is not literally in zero-gravity (0-g). To orbit, a body requires sufficient velocity so that centrifugal force exactly balances the force of gravity. Any satellite is in a state of free-fall around its parent body. An orbiter, crew and payload experience *weightlessness,* not 0-g, from their free-fall.

Gravity gradient stabilized—An orbiter is most stable when always aligned with Earth's gravity.

Inclination—The angle between the plane of the orbit and the equatorial plane.

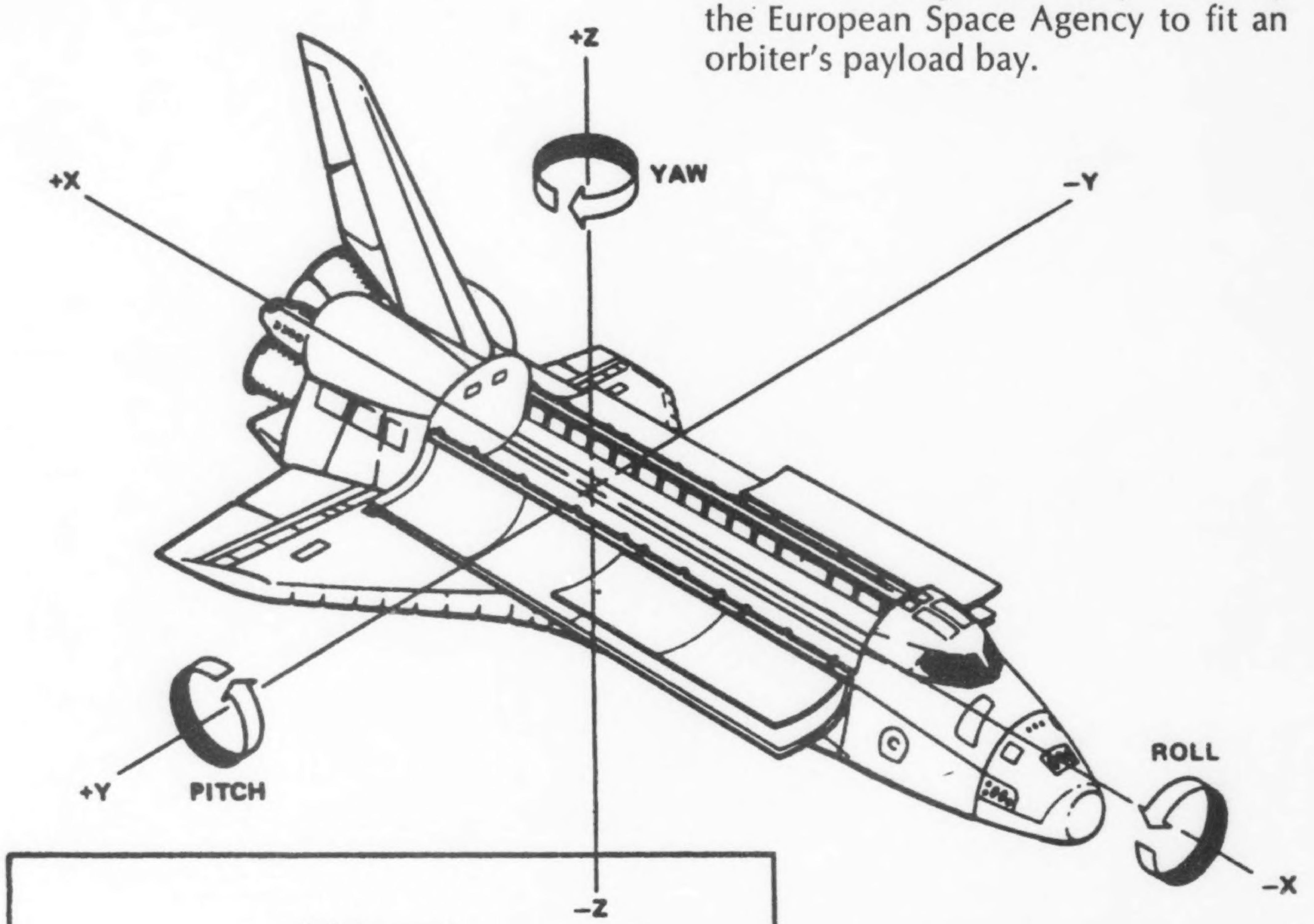
Ionosphere—The region of Earth's upper atmosphere where most orbiter flights will operate. Orbits may be in the E-region, the Heaviside-Kennelly layer (to 150 km); or in the F-region, the Appleton layer, at 150-400 km, the top of the ionosphere. With extra propellant and low-weight payloads, an orbiter can work in the Exosphere to altitudes of 1,200 km.

Inertial Upper Stage (IUS)—A solid propellant engine carried to low-Earth-orbit with a satellite which it then drives to higher orbits than the Shuttle system can reach.

Remote manipulator system (RMS)—Mechanical arm mounted on one side of the cargo bay, controlled from the orbiter aft flight deck, to deploy, retrieve or move payloads (pictures in *Air & Space* for March).

Solid rocket boosters (SRB)—The two solid-propellant rocket motors used during launch to augment thrust from the Space Shuttle Main Engines. These drop off at about 50 km altitude, parachute into the ocean, are recovered by ship and reused up to 10 times.

Spacelab—A general-purpose, variable-format orbiting laboratory built by the European Space Agency to fit an orbiter's payload bay.



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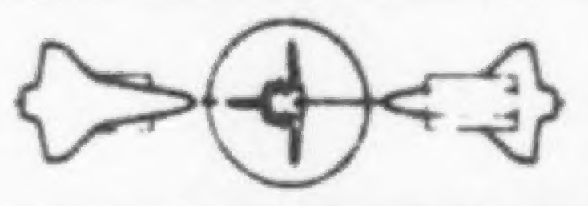
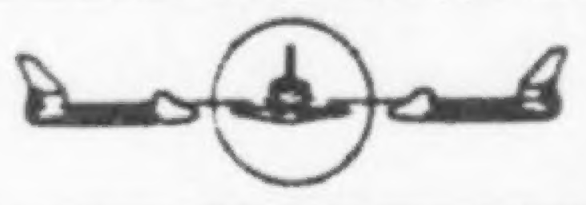
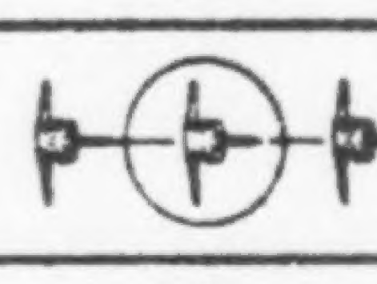
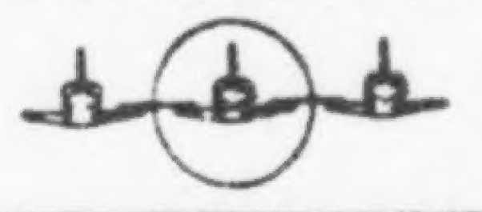
Gravity gradient stabilized	Y-POP, X-nadir	
	Z-POP, X-nadir	
Quasi-inertial (selected inertial attitude/attitude rate	Y-POP	
	Z-POP	

X, Y and Z mark
Orbiter axes. Sketches at left show which axis is perpendicular-to-the-orbit-plane (POP, the circles) in orientations toward Earth. When gravity-stabilized, an orbiter's nose always faces Earth. When drifting quasi-inertial, the same surface always faces the Sun, useful to keep heat radiators on top out of direct sunlight.

Mission—A coherent set of investigations or operations in space. A single mission might require more than one flight, or several missions may be accomplished on one flight.

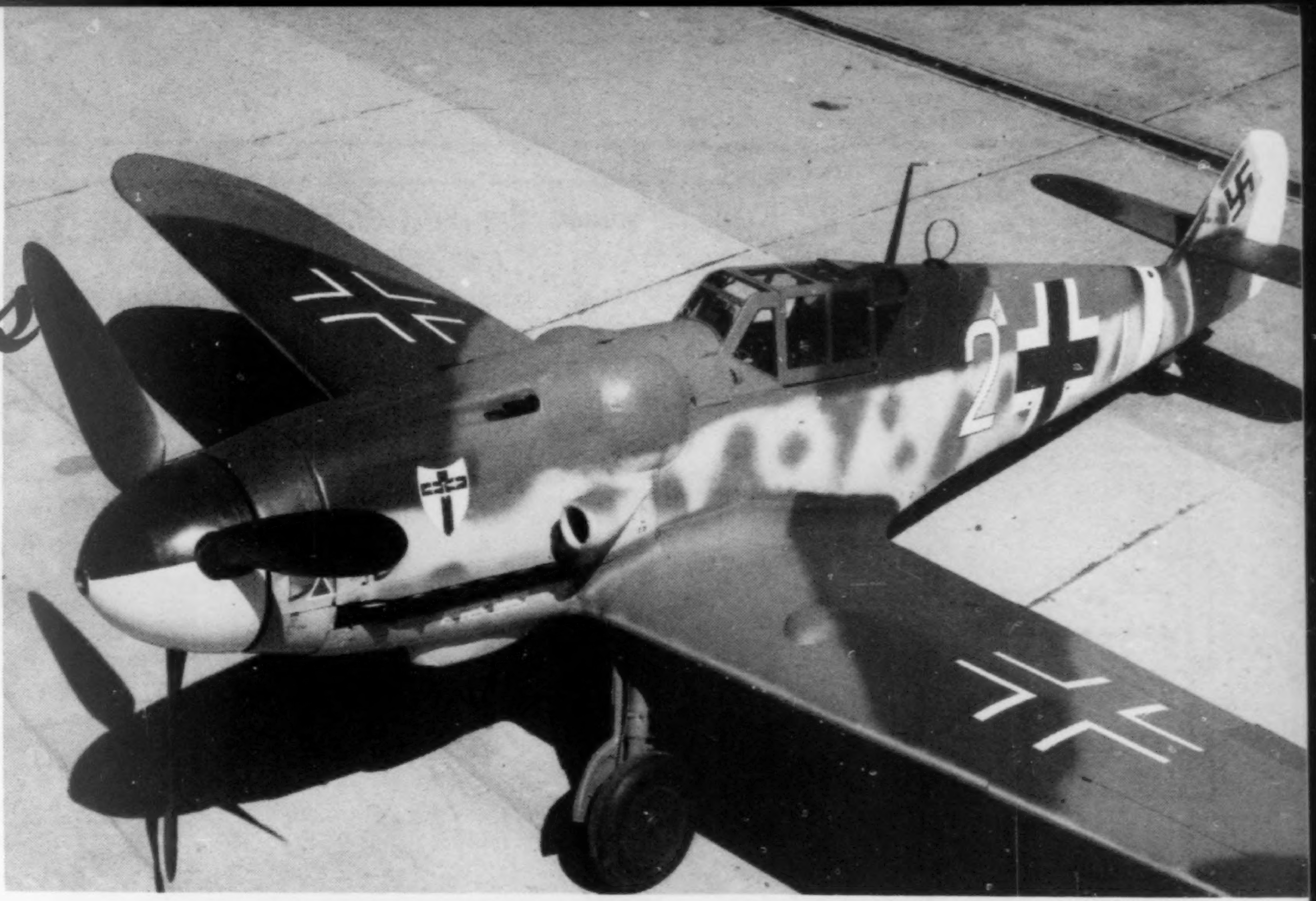
Orbital maneuvering system (OMS)—38 main thrusters and 6 small vernier thrusters used to maneuver an orbiter into different orbits; to rendezvous with a satellite, as for repair or to bring it back to Earth; to maintain a certain attitude; and to deorbit for return to Earth.

Space Shuttle Main Engine (SSME)—A cluster of three built into an orbiter will burn liquid hydrogen and liquid oxygen from the external tank for the main thrust of launch.

Spinning Solid Upper Stage (SSUS)—See IUS; another type of engine to propel satellites into orbits higher than that of an orbiter.

Vernier thruster—Small rocket motor for fine adjustment of velocity or trajectory of an orbiter and other spacecraft.

"Messerschmitts at 12 O'Clock!"



The restored Bf 109G at NASM, above, carries markings of the III./JG27 which operated in the Eastern Mediterranean, late 1943. Affectionately called "Gustav," the "G" was nicknamed "Beale" ("Bump") for the fairing in front of the cockpit which housed the two 13mm MG 131 machine guns.

by Robert C. Mikesh
Associate Curator
Department of Aeronautics, NASM

. . . German fighters were straight ahead, and Britain's Royal Air Force (RAF) pilots aligned their Spitfire gunsights on the enemy. Fighters from all directions crisscrossed the sky. The nimble Messerschmitt Bf 109 is still remembered throughout the world for its exploits during the epic Battle of Britain. It was the equal of any contemporary fighter in squadron service in the world, and superior to most.

The Messerschmitt Bf 109G in the National Air and Space Museum, pictured above, is a later version than the ones used during the Battle of Britain, but more "Gs" entered Luftwaffe service than any other variant.

Messerschmitt legends are perpetuated by the availability of a number of plastic model kits on the market. A true test of craftsmanship is in the construction of a "scratch-built" model, using raw materials found around the home or hobby shop. The drawings of NASM's Bf 109G are provided for the Industrial Arts class wishing to construct such a model with wood and other materials.

If a power jig saw is available, clear dry pine or bass wood is recommended over balsa wood, for it sands more smoothly and holds thin, sharp edges. If all shaping must be done by hand, balsa blocks and thin planks from hobby stores will do fine. From the drawing, trace the profile and top outlines of the fuselage on paper and cut out with scissors. Transfer this profile outline to the fuselage block, and saw or carve to shape, leaving a groove to admit the one-piece wing. Trace and cut the top outline by the same method. With a sharp knife, carve the rounded contours of the fuselage to match the cross-sections shown on the drawing, and smooth out with sandpaper.

Shape the block for the wing plan form in the same manner. Taper from the correct thickness at the center to the tip. When the airfoil has been carved and smoothly sanded, cut the wing in two and rejoin by gluing, holding the correct upward dihedral with blocks under each wing tip.

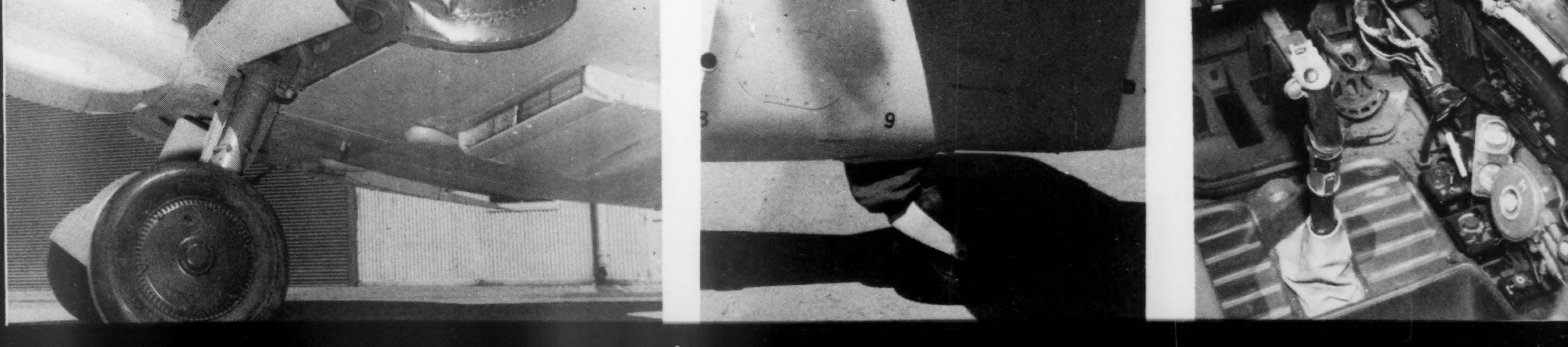
Form the tail, radiators, etc., from scrap wood, matching their shapes carefully to the drawing. Brass tubing, wire or wooden dowels form landing gears, and are set in holes drilled in the wing. Wheels can often be matched from a used plastic model kit or obtained from a hobby shop.

Glue parts together, checking alignment closely with the drawing. Fill seams and form fillets with modelbuilders' putty, and shape by sanding. Sand between several coats of sanding sealer to form a smooth surface, and the model is ready to be painted as shown in the pictures and on the drawing.

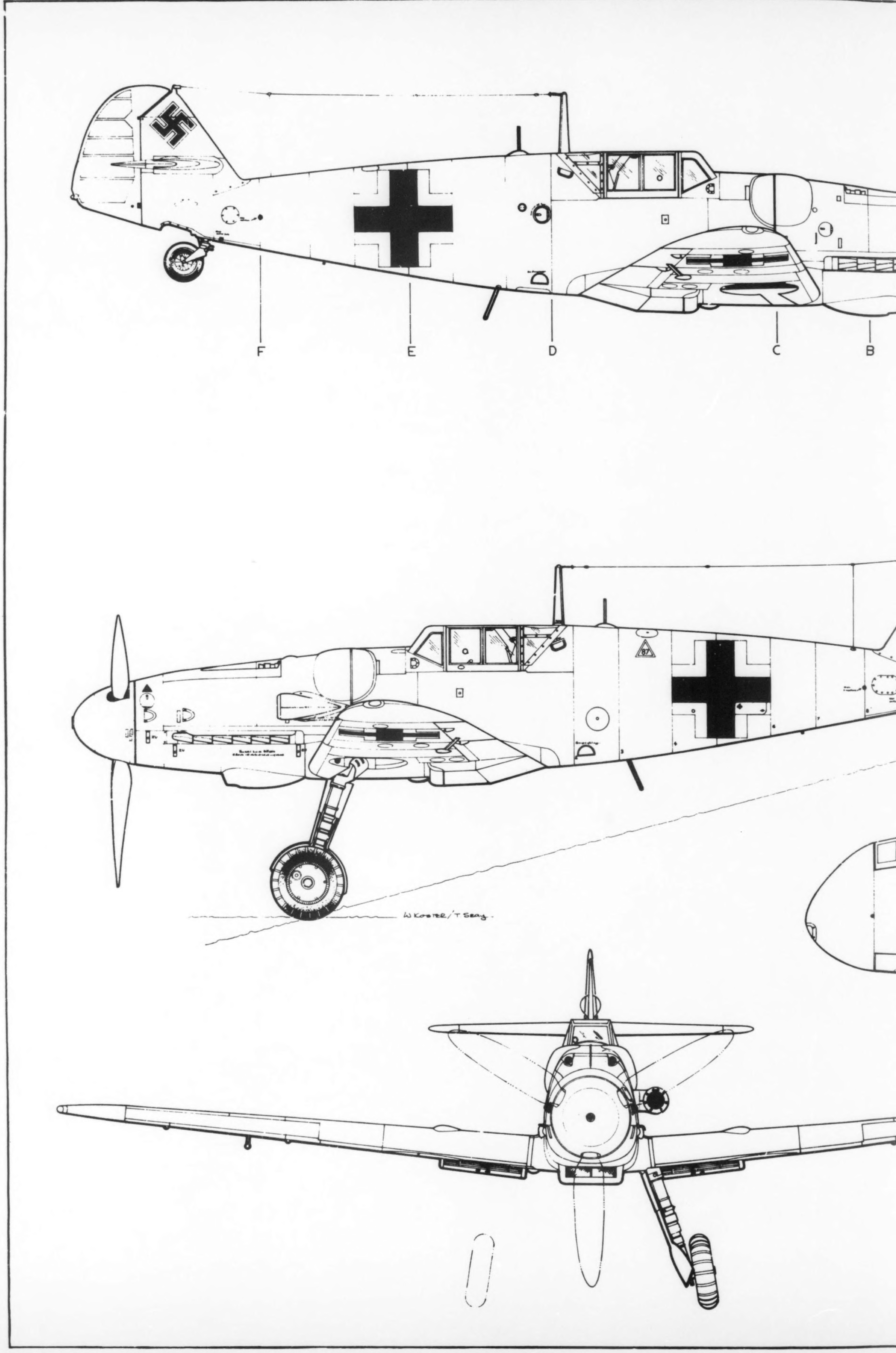
MODEL PLANS →

Information about the Bf 109 is found in *Aircraft of the National Air and Space Museum*, 8½ by 11 in., 136 pp., illus., descriptions of 16 notable planes. Smithsonian Institution Press, 1976, $2.75 including postage. Mail orders to NASM Rm. P701 (address, back cover).

Details for models: Below, laced leather in the dark gray wheel wells prevented landing field mud from building up in the wing; note exhaust pipes and underwing radiator. Right, the Werke Number (serial number of German aircraft) was painted on only the left side of the fin. Far right: Bf 109G cockpit.



MESSERSCHMITT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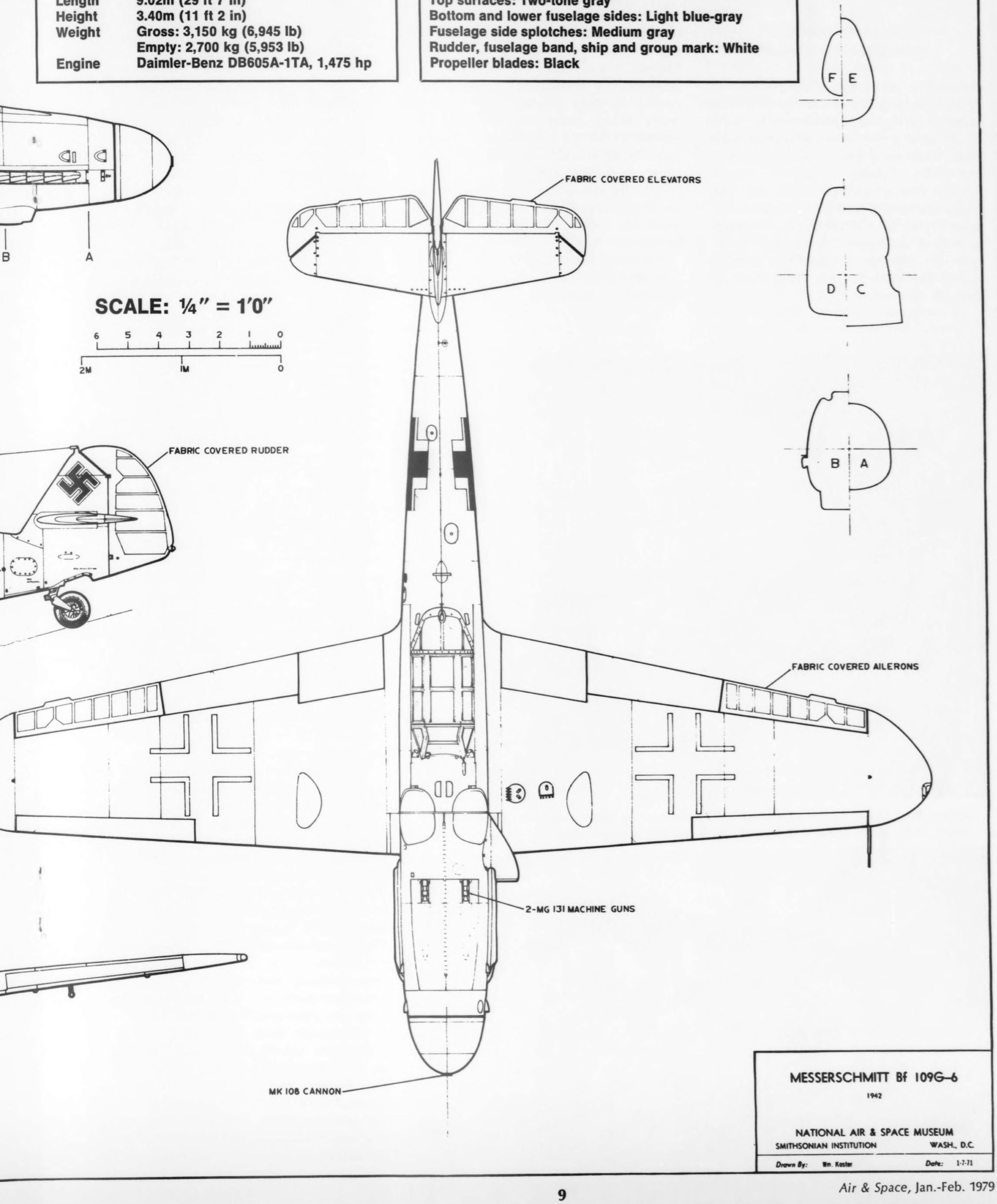
W Koster / T Seay.

MESSERSCHMITT Bf 109G SPECIFICATIONS:

Wingspan	9.92m (32 ft 6½ in)
Length	9.02m (29 ft 7 in)
Height	3.40m (11 ft 2 in)
Weight	Gross: 3,150 kg (6,945 lb) Empty: 2,700 kg (5,953 lb)
Engine	Daimler-Benz DB605A-1TA, 1,475 hp

CAMOUFLAGE COLORS for Bf 109G Interceptor Model
(All paint is flat finish.)

Top surfaces: Two-tone gray
Bottom and lower fuselage sides: Light blue-gray
Fuselage side splotches: Medium gray
Rudder, fuselage band, ship and group mark: White
Propeller blades: Black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2-MG 131 MACHINE GUNS
MK 108 CANNON
MESSERSCHMITT Bf 109G-6
1942
NATIONAL AIR & SPACE MUSEUM
SMITHSONIAN INSTITUTION
WASH., D.C.
Drawn By: Wm. Koster
Date: 1-7-71

Pioneers—the 99th Fighter Squadron

by Lonnie Bunch
NASM Education Division

Americans have an insatiable desire for knowledge about pioneers—individuals who challenge the unknown or who chart new paths. One group of pioneers deserving greater recognition is the 99th Fighter Squadron. These World War II airmen were the first black military pilots in American history. Trying to overcome racial bigotry as well as the enemy, these pilots compiled an enviable record. Their actions paved the way for the integration of the U.S. Air Force.

The Japanese attack on Pearl Harbor on December 7, 1941, propelled the United States into World War II. Immediately thousands of Americans rushed to their country's defense. To many black Americans, fighting the enemy in Europe or Asia was synonymous with winning equality at home. Much to the chagrin of aspiring black pilots, the Army Air Corps refused to accept blacks. Blacks were told, in no uncertain terms, that they were unfit for military flying.

The refusal to allow black entry into the Air Corps was a *cause celebre* in the black community. Leading black citizens registered their displeasure with letters and petitions to elected officials. The Army Air Corps finally reversed its decision, but only after the National Association for the Advancement of Colored People (NAACP) initiated legal action against the Corps.

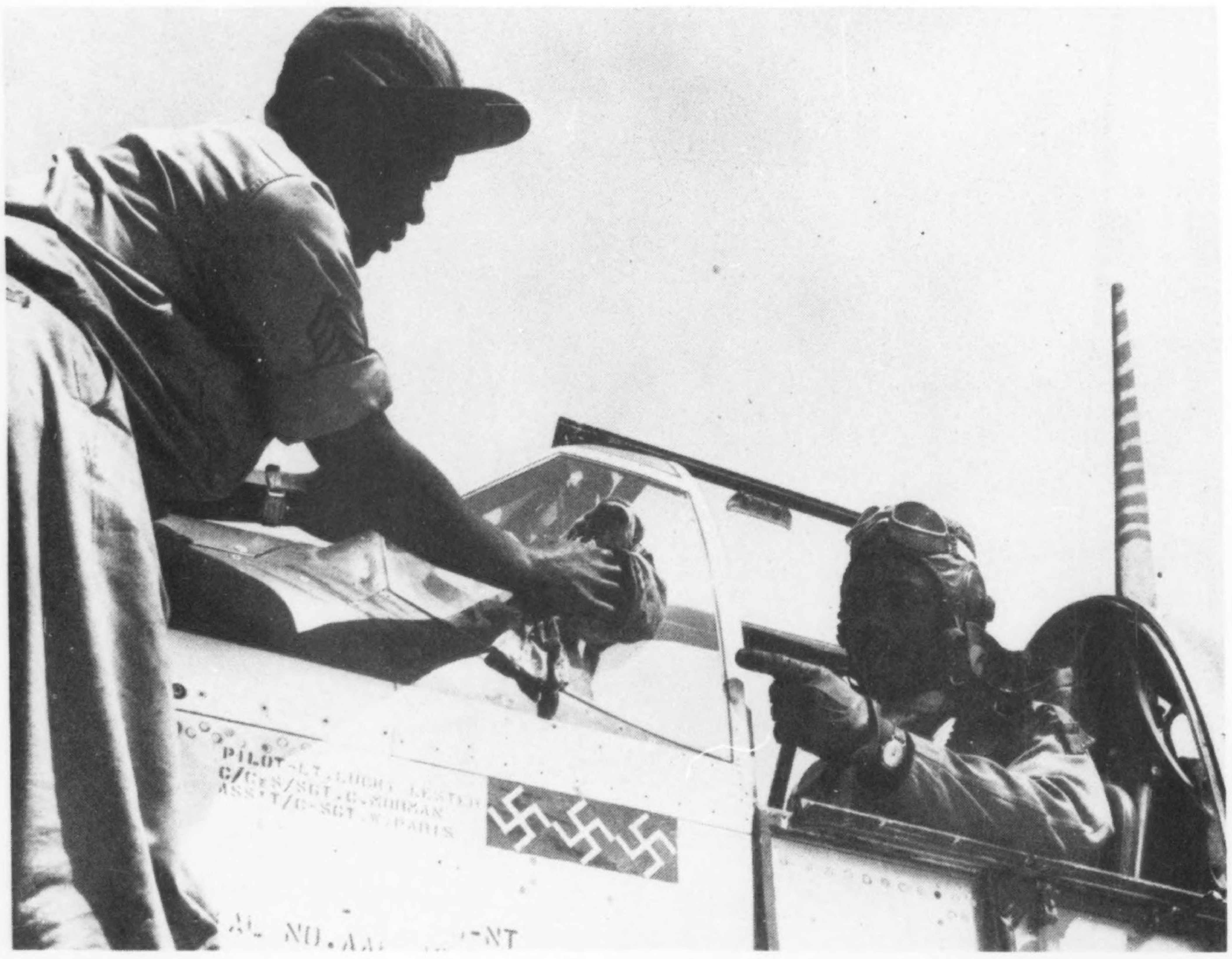
Blacks who enlisted in the Air Corps were segregated from their fellow pilots, and trained in all-black units. While the door was now open for black pilots, it was a different door than the one open to white pilots.

In March, 1942, the 99th Fighter Squadron was officially activated. Training for the cadets took place near Tuskegee Institute in Alabama. Thereafter the cadets bore the name "Tuskegee Airmen." The trainees received the same rigorous training as all air cadets in the Air Corps. Unlike their white counterparts, however, blacks who were accepted into the Corps were already pilots. Black cadets had to complete a Civilian Pilot Training program prior to enlistment.

After months of training, the Squadron, commanded by Benjamin O. Davis, Jr., was ready for overseas duty. As one pilot put it ". . . we were ready but they didn't know what to do with us." Finally stationed in North Africa, the 99th was assigned low-priority missions that prevented the group from receiving the acclaim that numerous victories brought. Critics quickly claimed that the black pilots were failures, and *Time Magazine* even called for the disbanding of the 99th. Eventually Colonel Davis was summoned to the Pentagon to defend the Squadron's performance.

The Squadron, however, was not without its supporters. Black Americans had not lost faith; black newspapers like the *Afro-American* chided the Army for misusing the Squadron. Eventually the Squadron received better assignments, and when they did, their performance improved. Fighting in Italy and North Africa, the Squadron won the respect of military men throughout Europe. The Squadron's performance was so good that it received (along with later black squadrons that made up the 332nd Fighter Group) a Distinguished Unit Citation.

Integration of all the Armed Forces proceeded rapidly in the late 1940's. In 1949, the 332nd Fighter Group was deactivated, and its personnel were integrated into the Air Force. Much of the credit, at least in the Air Force, is due to the pioneers of the 99th Fighter Squadron.



Above, Pilot Lucky Lester prepared for a mission; the three swastikas denote victories, evidence of flying and fighting skills. Below, a last-minute briefing for pilots.

OUTREACH

by Kerry M. Joëls

Chief, Education Division

The Briefing column, Page 2, asks: "What if?" Now there's the start to many questions that we'd like to pose. What if you could talk coast-to-coast on a two-way conversation for $1.00 an hour? What if you could transmit two-way video picture information for $2.50 an hour? What if you could have a computer terminal hooked up to major libraries and instantly get bibliographies or call-out articles from anywhere in the country for about $1.00 per hour of usage? What kind of impacts would this have on our ability as educators to provide interaction and additional material for our students?

If these questions stimulate you, let's look at some of the technology that the Space Shuttle may make available. A Shuttle can lift up to 29,500 kilograms of equipment into orbit. A rocket placed in orbit by a previous Shuttle flight could then boost this equipment up to geostationary Earth orbit. This payload could be a large communications satellite with a group of antennae capable of extremely sensitive reception and powerful transmission. The big brother to the satellite I have just described should be able to provide the services mentioned at the beginning of this article for the costs listed. This means that any teacher who would like to broadcast a classroom discussion, or receive information from another teacher, or visit with another classroom anywhere in the world within range, or receive any one of a choice of 1,000 different educational programs or video broadcast filmstrips in several languages, or hook up a small computer terminal and draw on information located hundreds of miles away from your classroom, may some day be able to do just these things.

The secret of inexpensive hook-ups is having a satellite big enough and powerful enough to make the terminal on the ground very inexpensive. Most people could afford a $50 antenna for their present television system to receive broadcasts from a powerful satellite. The more powerful the satellite, the less powerful your transmitter and equipment on Earth need be.

One of the things that has limited our use of educational television, computers, telephone conference and visiting lecturers is the expense of the system. A toll call by telephone contact can cost $10 to $20 per hour. But, with enough use, and enough separate channels, the cost of a communications satellite becomes very cheap.

I leave it to your imagination to decide what could be done with a computer terminal in your school library which has access to the combined knowledge of several university libraries, and large numbers of children's books and textbooks. What would your class learn from a visit with another class taught by a college friend of yours in another state or country, perhaps in a more urban or rural environment? What could you do with a random access system which would allow you to request broadcast of a film or filmstrip into your classroom at the date and time you wanted from a central media center? Would you like to go on the air and share a teaching technique or a classroom activity with some of your colleagues?

In its early stages the telephone was an oddity and a luxury, but through a vast reduction of cost and a streamlining of ways in which to hook telephones up, virtually every American household has one. This was a revolution in personal communication. The next revolution may involve a hook-up of individuals and classrooms via radio link through satellites which are always available overhead, and can, as a result of the Space Shuttle's lifting power, become powerful enough to bring about some of these opportunities.

How to Borrow Moon Rocks for Class Study

Samples of the Moon's surface, from rocks brought back by astronauts of the Apollo missions, may be borrowed for classroom use from NASA's Johnson Space Center (JSC) at no charge. With the lunar samples, JSC sends an 11-kilogram (25 lb) packet of literature, slides, audio-tape and film to help a teacher make the most of the loan.

Before being entrusted with the Moon rocks, teachers must attend a briefing which often lasts for three hours. These are held at NASA Centers; are given by NASA Science Specialists and/or other qualified persons; or are especially arranged in any area from which the NASA Centers receive a great number of inquiries.

Designed for Grades 5 through 12, six samples come in plastic disks an inch thick and six inches in diameter. These can be studied under ordinary 10X-20X microscopes. Grades 13 and higher receive six thin slice samples in plastic to be studied with high power microscopes.

Three booking offices are involved. All are at NASA Johnson Space Center, Houston, Texas 77058. Educators at planetariums and museums write to: Charles Biggs, Mail Code AP-4. Teachers of Grades 5 through 12 write to: James D. Poindexter, Mail Code AP-4. Teachers of Grade 13 up write to: Dr. Pat Butler, Lunar Curator's Office, Mail Code SN-2.

The slide sets are already booked for several months ahead; teachers should allow ample time in projecting class plans for these.

First Geologic Map of Mars Available

The first geologic map of the entire surface of the planet Mars may now be ordered at $1.50 from the U.S. Geological Survey, Branch of Distribution, 1200 South Eads St., Arlington, Virginia 22202, or from USGS, Federal Center, Denver, Colorado 80225.

The colorful 38 by 48-inch map identifies 23 types of rock, mountains, craters, plains, canyons and other features which suggest that Mars may have resembled Earth, in ages past, more than any other member of the Solar System. Color is used as a clue to relative ages of these features. The scale is 1:25,000,000, or about 644 km to 2.5 cm (400 miles to the inch). The map was made from more than 2,000 photographs taken by Mariner 9, the spacecraft which orbited the Red Planet in 1971-1972. USGS mapmakers say, "Data from the Viking spacecraft . . . appear to substantiate the overall picture presented by the map."

The UN and CTS

The "what ifs" posed in the Outreach column (Page 11) are based on successful trials already made with experimental communications satellites, such as the two most recent, known by their acronyms as ATS-6 and CTS. These are more sensitive and powerful than commercial communications satellites. Therefore they can receive from and transmit to smaller, less expensive, even portable ground stations. Recently, NASA's staff for CTS showed the United Nations the value of practically instantaneous sight-and-sound communication between distant points.

A UN conference in Buenos Aires, Argentina, was linked through CTS with UN headquarters in New York City. As is customary, simultaneous translations of speeches into five languages were provided to delegates in Buenos Aires, but this time, the translators remained in New York. They watched events as they happened (photo above) and returned their ongoing translations via CTS with a delay of two seconds.

Top, at the U.N., New York, NASA's van which houses a CTS receiving-transmitting station. Next, translators in New York watching a speaker in Buenos Aires. Below, conference delegates hearing simultaneous translations actually being made in New York.

ILLUSTRATION CREDITS
Front cover: Boeing Aerospace; poster from the Smithsonian's Museum of Science and Technology. Pages 2, 7, 8, 9, 10, 16: NASM. Page 7 closeups: Robert Mikesh. Pages 3, 4, 5, 6: NASA. Page 12: United Nations. Page 13: National Academy of Sciences.

> **"It is an absolute scandal . . .**
> **that 60 years after Einstein completed his theories,**
> **teachers still take students through the whole**
> **of Newtonian physics, and it isn't until college,**
> **usually, that other instructors say, 'Forget all that . . .'**
> **Young people should grow up with the idea of relativity.**
> **It's as though we taught in public schools**
> **that Earth is the center of the universe, then**
> **students who reach college begin to hear otherwise."**
>
> **Nigel Calder**
> **British writer, interpreter of science,**
> **speaking at NASM last October**

ALBERT EINSTEIN

Born March 14, 1879, Ulm, Germany. Died April 18, 1955, Princeton, New Jersey.

When many students' great-grandmothers were young, at the turn of the century, theoretical physicists were advancing into experiments that simply would not conform to the standard principles of the day. These were the laws of physics evolved by Isaac Newton (1642-1727). In his era, it was a triumph of intellect to have organized objective experience into laws about an absolute time and space in which objects move and interact. People still live very satisfactorily with Newton's view of the world; his laws work—on the scale of human experience. Nearly all technology is still based on these laws.

But more subtle questions about the nature of matter, the world and the universe were coming up when Albert Einstein proposed the Special Theory of Relativity in 1905 and by 1915, the General Theory of Relativity, his most noted papers. Through physics and mathematics, he set forth a view of nature beyond the scale of everyday human experience.

In recent decades, more powerful and more subtle tools have made it possible to test Einstein's physical concepts quantitatively. Research has been on both macroscopic and microscopic scales—in the astronomers' universe, and in the strange sub-atomic world glimpsed by high-energy physicists using atom-smashers.

Astronomers are acutely interested in Einstein's theories about gravitation, and apply them to phenomena they are seeing with more powerful telescopes, and with instruments aboard spacecraft above Earth's distorting atmosphere.

Dr. Nancy G. Roman is responsible for the scientific validity of NASA's experiments in astrophysics and rela-

Non-technical Readings About Einstein

"Einstein on Newton," Paul Forman, *in The Wilson Quarterly,* January 1979, Smithsonian Institution, SI 349, Washington, DC 20560. (In the same issue, reprint of a 1927 article by Einstein, "On Newton.")

The Universe and Dr. Einstein, Lincoln Barnett, with an admiring Foreword by Albert Einstein; paperback, 140 pp., illus., index, bibliography. A Mentor Book M71, New American Library of World Literature, Inc., New York, 1948, fourth printing 1953.

Einstein's Universe, Nigel Calder, a fresh approach to the exposition of relativity, making full use of the latest experiments and ideas; 170 pp., illus., index. Viking Press, New York, 1979.

Albert Einstein, Creator and Rebel, Banesh Hoffman, one of Einstein's scientific collaborators; paperback, 272 pp., illus., index. Plume Book, New American Library, Inc., reprint of hard cover by Viking Press, New York, 1973

Einstein, the man and his achievement, edited by G. J. Whitrow; scripts of three programs produced by the British Broadcasting Corporation; 94 pp., bibliography. Dover Publications, Inc., New York, 1967.

Clay model of sculptor Robert Berks' head of Einstein, to become part of a three-times-lifesize full figure. The statue was commissioned by the National Academy of Sciences and will be dedicated in April when it is installed on the lawn of the Academy, on Constitution Avenue in Washington, DC.

tivity. She is enthusiastic about "the possibilities which experiments in space may ultimately provide for checking Einstein's theories and for distinguishing between them and other competing 'improvements' over Newton."

Dr. R. F. C. Vessot at the Smithsonian-Harvard Center for Astrophysics wrote recently, "We can now expand our laboratory to span the entire solar system and use massive bodies and large distances to measure directly the changes caused by gravitation on time and dimensions."

To study the relativity of time, a scientist must have an extraordinarily accurate clock. The Smithsonian-Harvard Center developed one so precise that it would differ from another such device by less than two seconds every 100 million years. This "clock" is an atomic hydrogen MASER (Microwave Amplification by Stimulated Emission of Radiation). The Center and NASA flew such a MASER aboard a rocket arcing 10,000 kilometers into space. On the upward trip, gravity kept diminishing in a small but measureable way, and increased during descent. Oscillations of the flying MASER have been compared with those of similar instruments on the ground.

Was Einstein right when he predicted that an ideal clock in a strong gravitational field near a massive object would run more slowly than a similar clock far out in space, isolated from any such mass? The Center has discovered, with intricate computer calculations, that time did speed up, away from Earth, at a rate equivalent to about one second per 100 years. This will mean nothing to Shuttle commuters, but is a fact which could become significant on interplanetary voyages to massive objects such as Jupiter or Saturn.

Spacecraft are providing a longer baseline than ever before available for experiments—400 million miles, for instance, in a recent test. During 1975-1976, two Viking spacecraft chased the planet Mars and on arrival divided into two landers and two orbiters which have been radioing information about the Red Planet ever since. In November, 1977, Mars' orbit took it "behind" the Sun, 400 million miles away. As the planet disappeared, the Vikings' radio signals passed the edge of the Sun. According to Einstein, such signals should be bent and delayed by the Sun's gravitational field. They were. According to Dr. Irwin Shapiro of Massachusetts Institute of Technology, the principal investigator, Einstein's predictions were verified to an accuracy of 0.2 percent.

When a spacecraft approaches a planet on a straight course, its flight path begins to curve. Mr. Calder says the phenomenon is due to "the warping of the single, four-dimensional entity which Einstein called space-time." Dr. Roman says that "curved space-time" is usually just another way of talking about gravitational effects; only with very strong fields or with extreme accuracies is there any difference: "Extraordinary precision is needed to detect the difference between a spacecraft's actual path by a planet and that predicted by Newton's inverse square law."

At the other end of the scale, physicists build ever more powerful atom-smashers, accelerating sub-atomic particles nearly to the speed of light and recording the "splatter" when particles collide. "Actually, some of the energy in the motion forms new particles after the collision," Dr. Roman said to *Air & Space*. Einstein's most famous formula —$E=mc^2$—seems borne out by events on an unimaginably small scale.

So Einstein, born 100 years ago on March 14, left a new vision of the unity of matter and energy. The desk, the tree, the teacher—matter in all its forms is only a sort of "frozen energy." Einstein could make truth relative for different observers, and opened a new era in efforts to understand nature and phenomena.

Smithsonian researchers pooled their suggestions for the best non-technical reading about Einstein and offer the brief list below.

The Evolution of Physics, the Growth of Ideas from Early Concepts to Relativity and Quanta, Albert Einstein and Leopold Infeld; 319 pp., diagrams, index. Simon and Schuster, New York, 1938.

Albert Einstein: Philosopher-Scientist, Paul Arthur Schilpp, ed., essays by 25 authorities with commentary by Einstein; contains the only Einstein autobiography; 2 vol., 781 pp., index, list of the 445 writings by Einstein, and of material on Einstein published in the New York Times. Paperback, Open Court Publishing Co., La Salle, Illinois, third edition 1969.

Albert Einstein, His Work and Influence on Our World, Leopold Infeld, one of Einstein's scientific collaborators; 134 pp., index, bibliography. Charles Scribner's Sons, New York, 1950.

Einstein, The Life and Times, Ronald W. Clark; paperback, 864 pp., illus., index, sources, bibliography. Avon Books, New York 1972.

Relativity, the Special and the General Theory, a Popular Exposition, Albert Einstein, translated by Robert W. Lawson; paperback, 164 pp., index, appendices. Crown Publishers, Inc., New York 1961.

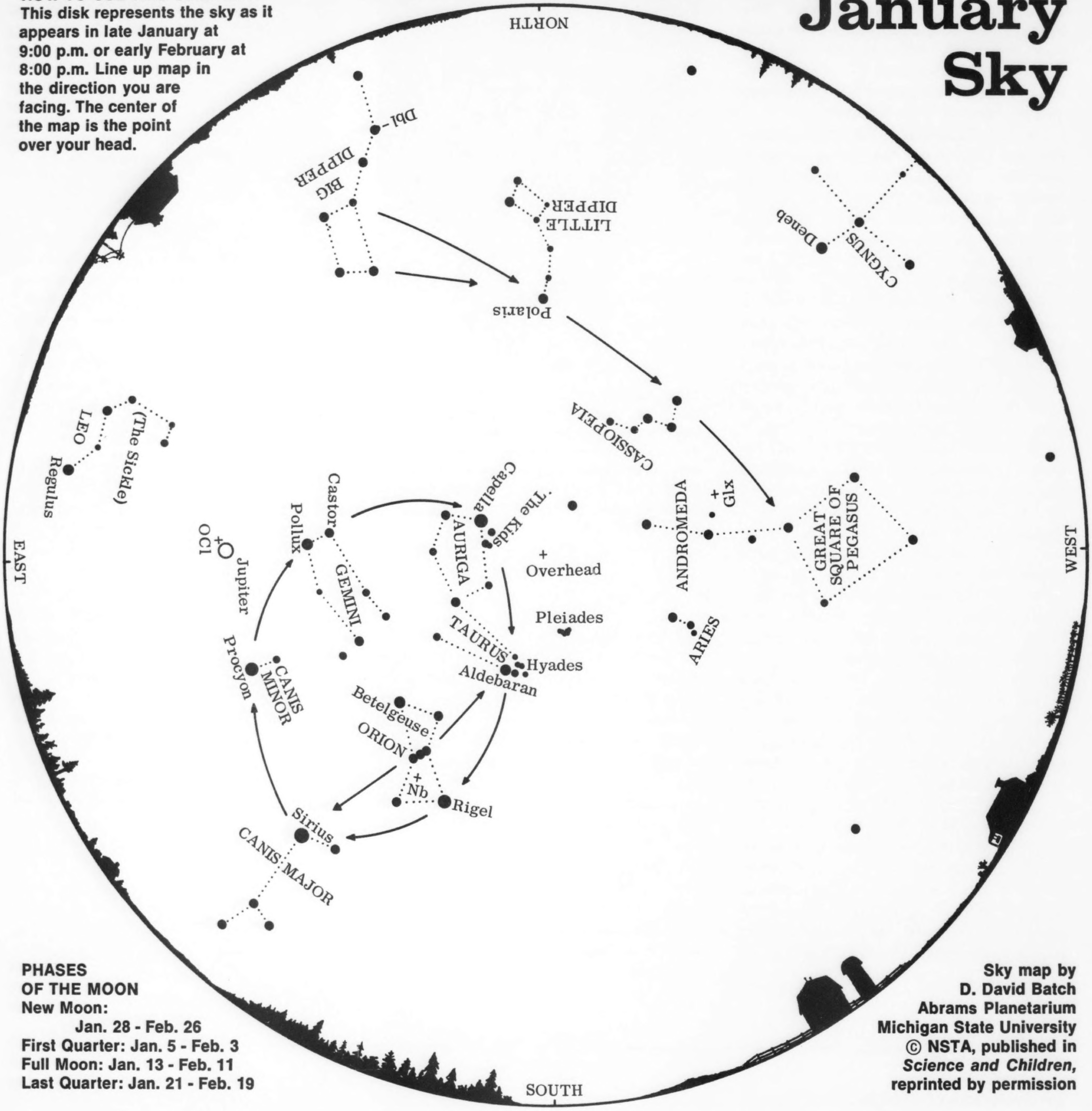
Einstein, His Life and Times, Philipp Frank (who knew Einstein well from an early date); 298 pp., illus., index. Knopf, New York, 1947.

Ideas and Opinions, Albert Einstein; complete general collection of his non-technical essays on science, people, politics, etc.; 377 pp., Bonanza Books, New York 1954.

The Born-Einstein Letters. Correspondence Between Albert Einstein and Max and Hedwig Born from 1916 to 1955, (physicist Max Born received a Nobel Prize in 1955) 240 pp., illus., index, Walker and Co., New York 1971.

January Sky

HOW TO USE THIS STAR MAP
This disk represents the sky as it appears in late January at 9:00 p.m. or early February at 8:00 p.m. Line up map in the direction you are facing. The center of the map is the point over your head.


NORTH
Dbl
BIG DIPPER
LITTLE DIPPER
Polaris
CYGNUS
Deneb
CASSIOPEIA
LEO
(The Sickle)
Regulus
Capella
The Kids
AURIGA
Castor
Pollux
GEMINI
OCl
Jupiter
+ Overhead
ANDROMEDA
Glx
GREAT SQUARE OF PEGASUS
EAST
WEST
Pleiades
TAURUS
Hyades
Aldebaran
ARIES
Procyon
CANIS MINOR
Betelgeuse
ORION
Nb
Rigel
Sirius
CANIS MAJOR
SOUTH

PHASES OF THE MOON
New Moon:
Jan. 28 - Feb. 26
First Quarter: Jan. 5 - Feb. 3
Full Moon: Jan. 13 - Feb. 11
Last Quarter: Jan. 21 - Feb. 19

Sky map by
D. David Batch
Abrams Planetarium
Michigan State University
© NSTA, published in *Science and Children,* reprinted by permission

by Dennis L. Mammana
Staff Astronomer
Flandrau Planetarium, Tucson, Arizona

The winter sky offers the most brilliant stars of any season. The entire constellation of Orion can be called a "star factory" since new stars are slowly being born within the globs of gas and dust in that region. If you look toward Orion's center, just below the three belt stars that form a straight line, you will find a faint hazy patch of light; this is the Great Orion Nebula, a gigantic stellar incubator many times larger than our entire solar system.

Following the three belt stars of Orion upward leads directly to Aldebaran, the reddish-orange star marking the fiery eye of Taurus the Bull. Following the stars downward leads to bluish-white Sirius, the brightest star in the night.

The most spectacular celestial event this month, however, occurs not at night but in daylight. On February 26, the Moon will pass in front of the Sun and cause a solar eclipse. Most of the U.S. will experience only a partial eclipse, but along a narrow stretch of land in the northwest states, there will occur one of the most awesome events in nature—a total solar eclipse.

Observing a solar eclipse can be very dangerous and requires care. You must NEVER look directly at the Sun, not even a partially eclipsed Sun, not even for a moment. Eye damage and even total blindness can result. Only the totally eclipsed Sun is entirely safe to look at. The safest method is by projection. Put a pinhole in a piece of cardboard and, holding it up to the Sun, project the Sun's tiny image onto a shaded piece of white cardboard, and watch the majestic eclipse take place.

To learn the times of the eclipse in various parts of the U.S., check with a local observatory, planetarium, weather bureau, or newspaper.

THE EXPANDING DOMAIN

Continued from Page 3

—in drop towers (long, evacuated cylinders) or on board aircraft flying certain trajectories. Sounding rockets can carry small payloads into space and arc back to Earth, providing about five minutes of weightlessness. For a week or a month of it, an experimenter has to go to space.

Gravity is so taken for granted that students might enjoy imagining what some familiar experiments would be like if there were no sedimentation, no convection, or, in organisms, no need for a support structure.

Only 64 experiments in basic science and processing have been performed during U.S. space missions—36 aboard Skylab, 28 during the Apollo-Soyuz mission. Reviewing them, some scientists and industrialists conclude that little of economic value is apt to come from space processing, but rather, a better insight into the nature of materials which would lead to better processing on Earth.

Other reviewers exclaim that such critics "will eat their words, within the decade," and speak of a new industrial revolution—manufacturing in space. At any rate, about 30 Shuttle trips are already booked.

When the human investigator can stay for longer periods in weightlessness and watch longer-term experiments, or put experiments on a free-flying platform for as long as a year, who knows what will be discovered? At his first press conference, NASA Administrator Robert A. Frosch called for patience, to wait and see what develops during the early routine usage of space.

Sources of Help for Making and Flying Models

The elation over actually flying model rockets has led many a student directly into physics, math, aerodynamics or electronics. According to the National Association of Rocketry (NAR), more than 100 million model rockets have been launched since 1957 with no serious injuries. NAR, a nationwide organization, has been active in setting safety standards for the hobby, in certifying model rocket motors, and in arranging for liability insurance. Members and chartered sections can now secure $1 million policies. Information on the NAR's educational programs is available from: National Association of Rocketry, P. O. Box 725, New Providence, New Jersey 07974.

Two other groups with membership programs are the International Plastic Modelers' Society, P. O. Box 2555, Long Beach, California 90801; and the Academy of Model Aeronautics, 815 15th Street NW, Washington, DC 20005.

FILMS

Filmmaker Ben Shedd says of his photographing the development of the Gossamer Condor (above): "It was like finding the Wright brothers before they built their first gliders, and following them, camera in hand, all the way to Kitty Hawk." Shedd began documenting construction of a man-powered plane a year before the Condor, now on exhibit at NASM, made history completing the Kremer Prize course, August 23, 1977. The 27-minute, 16 mm, color, sound film is distributed by Churchill Films, Inc., 662 N. Robertson Blvd., Los Angeles, California 90069, and at present is only available for sale.

A communications satellite film may be borrowed at no cost except return postage. *Pathways to the World* is sponsored by Communications Satellite Corporation (COMSAT), U.S. member and manager of the 102-nation INTELSAT group which owns the global network for telephone and TV service. Arthur C. Clarke, who originated the concept of geostationary communications satellites decades ago, opens the film from his home in Sri Lanka. The 27½ minute, 16 mm, color, sound film is booked through Modern Talking Picture Service, 2323 New Hyde Park Road, New Hyde Park, NY 11042.

Air & Space Registration Procedures

The National Air and Space Museum (NASM) is pleased that *Air & Space* has been so well received. New registrations arrive at the rate of some 5,000 per issue. These names are added to the mailing list **as quickly as possible.** (But some registrants may not receive the issue immediately following.) All other requests and queries should be included in a separate letter.

Requests to this Museum for aerospace photographs and any information except that concerning *Air & Space* should be addressed to the Library, Room 3105, NASM (address, back cover).

Requests for NASM posters, postal covers, materials lists and merchandise should go to Room P-701, NASM (address, back cover).

NASM is often confused with NASA. Educators' requests meant for the National Aeronautics and Space Administration should be addressed to NASA Headquarters, Code LFG-13, Washington, DC 20546.

The following information will answer questions most often asked:

Schedule: *Air & Space* is a bimonthly, September to May (no July-August issue). Volume numbers are by school year.

Cost: None. *Air & Space* is free to those who qualify, and is not sold to others.

Those who qualify: Educators, aerospace writers, librarians, public representatives of aerospace organizations, and collegians preparing to become teachers. Copies cannot be sent to or for use by students; issues may be freely photocopied for classroom work.

Requests for a sample, or evaluation copy: One only will be mailed, with a letter advising that permanent registration requires another, specific request.

Specific requests to be added to the mailing list: Send (1) name and address printed in block form as they should appear on the mailing label, with mail or zip code; (2) information as to **Position** (administrator, teacher, librarian, editor, etc.); **Subjects** covered (sciences, aerospace, other); **Levels** (elementary or under, high school, university or adult, or wide range); and **Affiliation** (school, professional society, government, or business). Registrations cannot be processed without this information.

Duration of registration: The listing is maintained indefinitely (subject to future check by NASM). It is not necessary to re-register each school year.

Bulk mailings: Individual registrations are preferred (as to each branch library, each teacher). One-time packages may be available for aerospace education workshops, etc., if requested in advance.

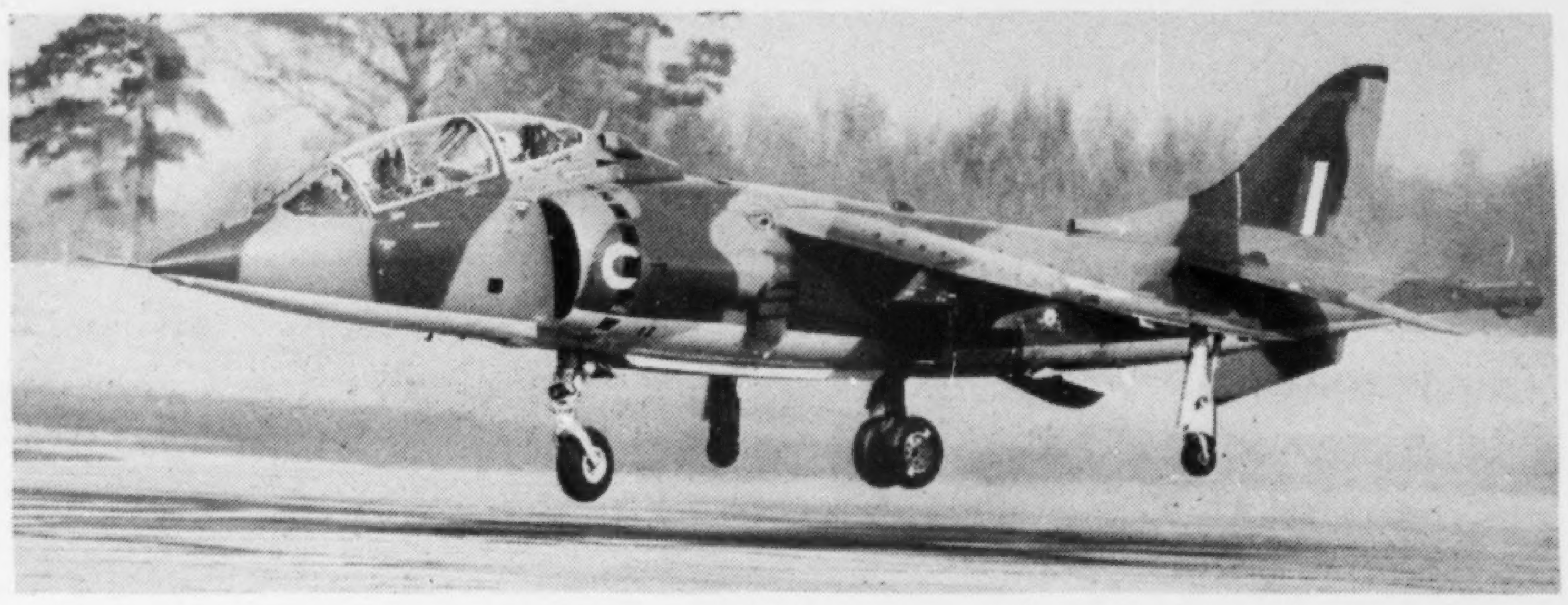
Changes of address/corrections: Send a label, or copy all information, especially the long coded line on the label.

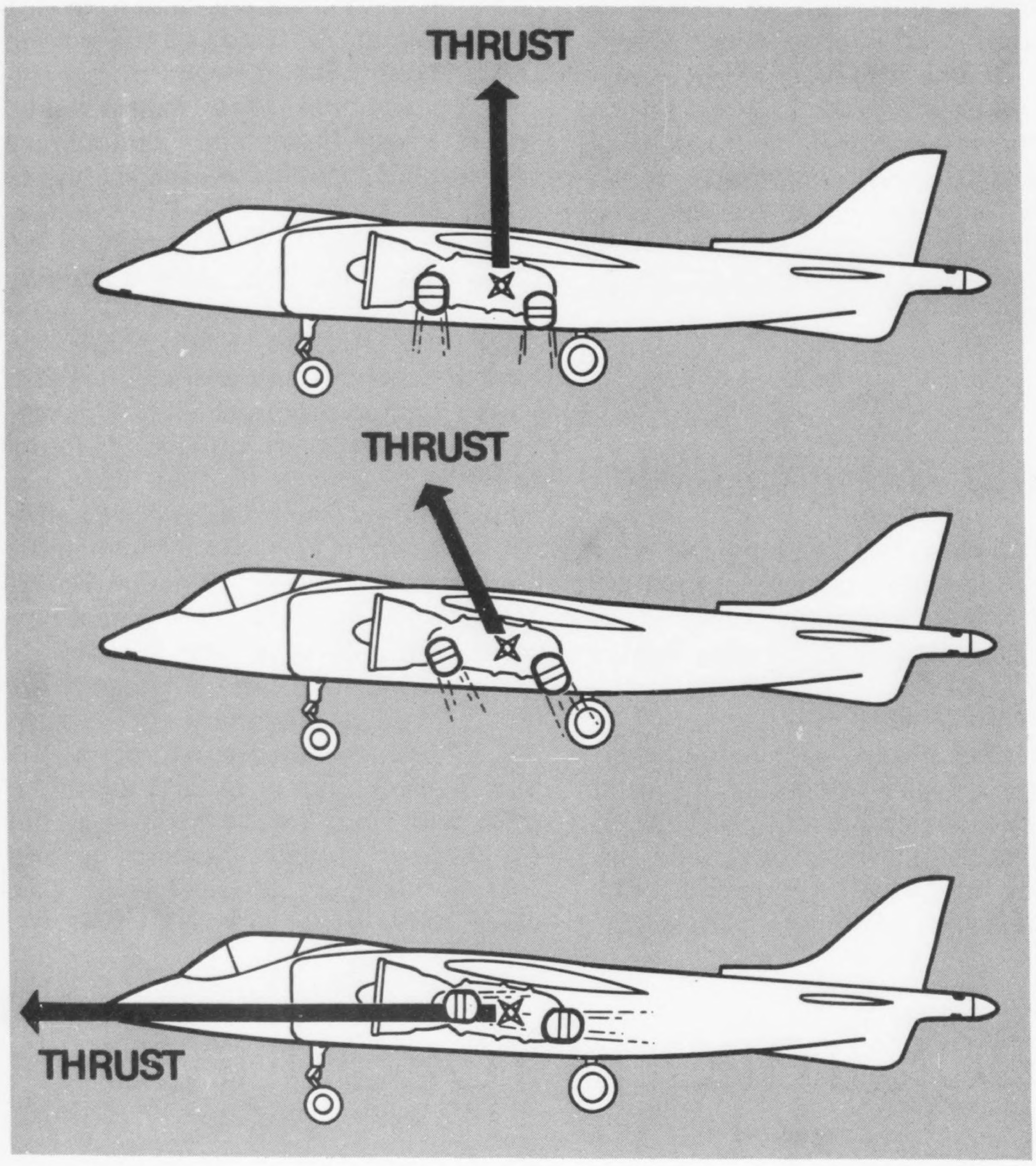
Back issues: NASM cannot supply. These are available in microfilm form from University Microfilms International, Inc., 300 N. Zeeb Road, Ann Arbor, Michigan 48106. (No more copies available of *Pioneer Venus Press Kit* or *Using Satellites in the Classroom.)*

Unneeded duplicate mailings: NASM will appreciate the return of the *unwanted* label.

THINK ALONG WITH THE AEROSPACE ENGINEERS

on how to design an ideal airplane, able to take off vertically, fly at very high speed, and land vertically. While helicopters meet the takeoff and landing requirements, they are limited in speed.





by Donald S. Lopez
Assistant Director for Aeronautics, NASM

One successful approach to this problem, the use of vectored thrust, is exemplified in the British Aerospace Harrier. In a conventional jet airplane, the exhaust gases of the engine or engines are directed rearward through a nozzle and the resultant thrust is in the forward direction. The Pegasus fanjet of the Harrier has four nozzles that can rotate downward through 110 degrees from straight to the rear. Two of these nozzles (hot nozzles) eject exhaust gases, and two (cold nozzles) eject air from the fan. Since thrust is produced in a direction opposite to the direction of the ejected gases, the thrust is forward when the nozzles point backward, and upward when the nozzles point downward.

By controlling the direction of the thrust, the Harrier, when lightly loaded, can take off vertically, hover, make a transition to high-speed aerodynamic flight, and return to a vertical landing. When heavily loaded at the start of a mission, the nozzles can be directed downward during the takeoff to shorten the roll considerably. It can accomplish carrier takeoffs and landings without catapults or arresting cables.

To control the aircraft when the forward speed is insufficient for aerodynamic control, a reaction control system similar to those in spacecraft is used.

The Hawker Siddeley Kestrel, a forerunner of the Harrier, is displayed in NASM's Gallery of Flight Testing.

Air & Space, Jan.-Feb. 1979

NATIONAL AIR AND SPACE MUSEUM
THE SMITHSONIAN INSTITUTION
WASHINGTON, DC 20560
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Kerry M. Joëls, Chief, Education Division
Julie Forbush, *Air & Space* Editor, Room 3569